COMPUTER SIMULATION OF A COTTON PRODUCTION SYSTEM

Users Manual

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This publication reports work done under Regional Research Project S-69, "Engineering Systems for Cotton Production," a joint effort of the Agricultural Research Service, U.S. Department of Agriculture, and the State agricultural experiment stations of Alabama, Arizona, Arkansas, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas. The State experiment station research was supported in part by allotments from the Regional Research Fund established by the Hatch Act, as amended August 11, 1955, and administered by the Cooperative State Research Service, U.S. Department of Agriculture.

Applicants for all Department programs will be given equal consideration without regard to race, color, sex, creed, or national origin.

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PART 1.—SCOPE AND APPLICATION

By Rex F. Colwick and James W. Jones[2]

There has been considerable interest in computer simulation of productivity, energy flow, water use, and pollution in the many different ecosystems over the earth's surface. Much of this work has been stimulated by the International Biological Program (IBP) and is oriented toward better management of the earth's resources. We report here considerable progress, independent of IBP, toward the modeling and simulation of cotton production systems.

There are several justifications for computer simulation of a large system. First, computer models focus attention on areas where knowledge is lacking and assist in the planning and management of team research. Second, these models are useful experimental aids for studying hypotheses about system relationships, allowing better understanding of the numerous components of a system and thus reducing the cost of applied research. Ultimately, in showing the relationships among system components, computer models form a base for sound management decisions and alternatives.

Our work commenced with the organization of Regional Research Project S-69, "Engineering Systems for Cotton Production," in 1968. No one researcher can have a comprehensive understanding of the structure and operation of each component of a crop production system, and this project has provided coordination among a number of researchers in developing a cotton production simulation model. Since its inception, many experimentalists have joined the effort to build data bases for submodels, and many are also using parts of the system to study large ecosystems.

This publication describes four simulation models of subsystems in the cotton production system. These models, encompassing seedbed preparation through harvesting and ginning, were interfaced for the first computer simulation of any crop production system in October 1973.[3] Our research group is close to completing some insect management models that will soon be added to the simulation.

The first model simulates the soil-moisture profile in the seed zone (MOIST). It is a description of the moisture flux based on the conservation of water in the top 6 inches of soil. Water evaporates from a visible moisture front as the water diffuses through a layer of dry soil and is partially replaced by capillary water that moves from a moist region to a dry region in response to a moisture gradient. This model provides the moisture input to the following model, EMERGE.

EMERGE describes the germination and emergence of the seed. It is controlled by soil-moisture tension, soil temperature at the seed depth, and the mechanical impedence of the surface soil. When the model has simulated 50% seedling emergence, the plant model, SIMCOT II, is initiated.

SIMCOT II is based on conservation principles that include a carbohydrate balance, a moisture balance, and a nitrogen balance for the plant. It requires daily inputs of solar radiation, maximum and minimum air temperatures, rainfall, pan evaporation, plant population, water-holding capacity of the soil, nitrogen application rates and dates of application, and plant growth factors related to carbohydrate, water, and nitrogen balances. Daily outputs from this model include plant weight, the number of fruit, and the age and location of each fruit on the plant.

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[3] Bowen, H. D., Colwick, R. F., and Batchelder, D. G. 1973. Computer simulation of crop production: Potential and hazards. Agric. Eng. 54 (10): 42–45.

Boll opening rate curves from this model can be used to initiate the harvesting process described in the last model, HARVSIM.

HARVSIM is a single-farm harvesting model that simulates passes made in the fields by the harvesters, the selection of trailers for filling, the transporting of trailers to the gin and of empty trailers to the farm, and gin backlog. An option includes twice-over harvesting in which the second harvesting of a given field occurs only if the remaining cotton would yield more than a specified amount. The model takes the cotton on through the ginning process and is capable of assigning economic values to the end product.

These models are in various stages of validation.

MOIST was verified for only one soil type and at one location primarily because the soil parameters necessary for additional verification are lacking; however, soil parameters are being developed for approximately 20 soils that represent about 80% of the cotton farmland in the United States. Some of these data should be available in 1975.

EMERGE was tested in five States for 2 or more years and produced satisfactory to excellent simulations in years in which the temperature increased progressively as the season advanced. Subsequently, a slight modification improved the simulation when a long cold period followed a warm period 2 or 3 days after planting. This modification needs more testing under various field and weather conditions.

SIMCOT II was tested at several locations, and when detailed mappings of the plant structure had been recorded twice a week and the environment had been monitored accurately, there was good correspondence between observed and simulated plant development, fruiting characteristics, and yield. More testing is needed particularly in the area of water stress, and more development is needed to apply this model to a field growth situation.

HARVSIM was tested for 2 years in the High Plains of Texas. Data for the first year show an excellent correspondence between simulation and observation. Second-year data have not been analyzed.

Although these models are in various stages of development and verification, this users manual is presented to document progress to date and to offer these models to scientists as a tool which they may use to focus attention on aspects of the system where understanding is limited. This should help them identify missing links and assign research priorities.

These models are not sufficiently developed and tested to assist cotton producers with management decisions. Such use could result in economic losses. The full management capabilities of crop simulation will not be achieved until all major crops have been modeled. Furthermore, a number of submodels dealing with insects, diseases, root development, nutrients, and water relationships will be essential for producer decisions. These are under development.

To interface crop production submodels easily, it is possible to make simplifying assumptions based on the objective of the interface. This approach was successfully used to interface the four models described herein. In figure 1–1 crop management is shown as it relates to the cotton production system. Options were designed for running any combination of the models when the user specified appropriate inputs. For example, SIMCOT II could be run alone or with EMERGE and MOIST, or MOIST could be run alone. The integrated models were run to test hypothetical situations such as a 10-day cold spell following planting, which resulted in a realistic delay in maturity and a decrease in yield.

A simulation of planting through harvesting provided very interesting results. However, the assumptions that were made will probably not be sufficient for all applications of the model. For example, MOIST and EMERGE were interfaced to provide soil-moisture values. It was assumed that (1) the seed and seedling do not alter the soil-moisture-flux equations, (2) the soil temperature can be predicted from air temperature, (3) the relative humidity can be predicted from maximum and minimum air temperatures, the dew point temperature of the previous day, and rainfall, and (4) physical impedence is known. MOIST provided a table of the hourly moisture contents at planting depth; however, EMERGE required moisture tension values in bars as input. To use the interfaced models, a soil moisture-soil tension relationship and a moisture release equation are needed for the soil being tested.

These equations are being developed for 20 soils, as mentioned above, at North Carolina

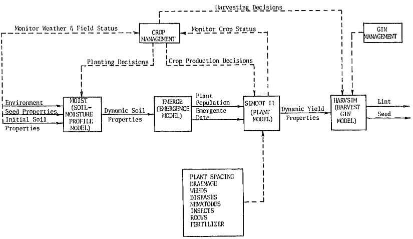

FIGURE 1-1.—Schematic of initial interface of MOIST, EMERGE, SIMCOT II, and HARVSIM.

State University. Also, Henry D. Bowen and others at North Carolina State University are attempting to obtain enough data so that EMERGE can be used without having to measure moisture, temperature, and physical impedence daily. This technique will be based on soil types and will be developed from National Weather Service information and the reaction of the soil to initializing inputs of moisture, temperature, and physical impedence.

SIMCOT II was initiated when MOIST-EMERGE predicted 50% emergence. It was assumed that from this point carbohydrate production and assimilation would be the controlling factor in plant development. A major assumption was that a single plant can be used to make predictions of growth and yield; the variability among plants, their competition, and environmental variability were not considered. Again, depending on the objective, this may or may not be suitable. Also, no insect models were integrated into this initial effort.

SIMCOT II predicted the boll opening rate used as input to HARVSIM. For this interface it was assumed that (1) no preharvest chemical aids had been used and that (2) nothing happened to the plant except the removal of open bolls. Both assumptions were based on considerable past research, but for some applications they may be unacceptable.

Considerable work remains to be done to interface these and other models at the field level. In many cases, detailed models of interactions of various physical and biological systems will be just as complicated as any of the independent models. For example, interfacing an insect population dynamics model with a crop model might be accomplished by modeling the behavior and metabolism of the insects as influenced by weather, crop factors, and insect preferences. Such an interface would allow detailed studies of the interactions and provide needed assumptions and relationships for higher level models.

An ultimate goal of these models, as mentioned earlier, is to optimize crop production systems. In addition, they will provide information for farm management decision models. Optimization models require a statement of what is to be optimized. At the producer (farm) level, profits are generally optimized (maximized) subject to the constraints particular to a given farm. However, researchers may study an optimization model designed to maximize yield or minimize production cost at the crop model level.

PART 2.—MOIST: A SIMULATION OF THE MOISTURE PROFILE OF A BARE SOIL AFTER PLANTING

By Charlie G. Coble,[1] Henry D. Bowen,[2] and Henry L. King, Jr.[3]

DESCRIPTION

MOIST is a computerized mathematical model for predicting soil water profiles during the drying of soil. It accounts for water movement in the soil in both the liquid and the vapor states and the evaporation of water to the atmosphere.

Liquid water movement is computed with the soil water diffusivity equation:

$$J_c=-D(\Theta)\frac{d\Theta}{dx},$$

where J_c=flux of water in grams per second per square centimeter,

(Θ)=soil water diffusivity in square centimeters per second,

$D(\Theta)$=water content in cubic centimeters per cubic centimeter of soil,

and $\frac{d\Theta}{dx}$=gradient of water content in cubic centimeters per cubic centimeter of soil per centimeter of distance.

The transfer of water in the vapor state because of temperature gradients is calculated with the equation

$$J_v=-D\frac{dC}{dx}-L_{ve}\frac{d(\ln T)}{dx},$$

where J_v=flux of water vapor in grams per second square centimeter,

D=diffusion coefficient of water vapor in soil matrix in square centimeters per second,

C=concentration of water vapor in soil air or atmospheric air in grams per cubic centimeter of air,

$\frac{dC}{dx}$=gradient of concentration of water vapor in soil air and in atmosphere in grams per cubic centimeter, per centimeter of distance,

L_{ve}=coupling coefficient between water vapor and heat energy in moles per second square centimeter,

T=temperature in degrees Kelvin,

and x=distance over which diffusion is occurring in centimeters.

The water evaporated to the atmosphere is controlled by vapor diffusion through the dry overlying soil layer and is calculated with the equation

$$J_e=-D\frac{dC}{dx},$$

where J_e=evaporation flux as water vapor diffusing through soil from visible moisture front to soil surface in grams per second square centimeter,

D=diffusion coefficient for water vapor through soil matrix in square centimeters per second,

and $\frac{dC}{dx}$=concentration gradient of moisture in soil air from visible moisture front to soil surface in grams per cubic centimeter per centimeter of distance.

Inputs to the simulation are weather and soil data (air temperature, atmospheric relative humidity, soil temperature, water vapor diffusion coefficients in soil, soil water diffusivities, soil bulk density, and energy-mass coupling coefficients).

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[3] Research assistant, North Carolina State University, Raleigh, N.C. 27607.

The model was verified for use on Ruston loamy sand soil and is adaptable to other soils. It can be used to accurately assess the effect of cultural practices on the soil water content profiles in drying soil. It was used to examine the effects of bulk density, wind, liquid water conductivity barriers, and surface films on the soil water content profiles under drying conditions.

The costs of using the model to optimize a cultural practice, including the cost of empirical verification of results, are estimated to be 0.01 to 0.1 of those required for obtaining the same information by empirical methods alone.

LIMITATIONS

The major limitation of MOIST is the large number of temperatures and relative humidities required for the program. For instance, with 15 soil layers, air temperature, and relative humidity, there are 408 items per day of input. Just obtaining the data is a major operation, and then it must be punched in. However, for in-depth studies of moisture movement in the top inch of soil, these data are required. A second limitation is that the soil parameters necessary for the program are available only for a Ruston loamy sand soil.

The thermal vapor section of the program is not very important in humid regions except possibly in the surface inch or less of soil and for high-radiation conditions. For large-seed crops, such as cotton, corn, soybeans, and peanuts, this section can probably be bypassed without serious error, but it will probably be necessary for small-seed crops planted at shallow depths. Where the vapor transfer can be bypassed, it is not necessary to have temperature inputs for all layers, but only for the visible drying front, for which air and soil temperatures are required. If the thermal vapor transfer is bypassed, the mass-energy coupling coefficient also need not be obtained. By using a constant temperature throughout the soil profile, the thermal gradient is bypassed. This is usually some function of air temperature, such as TA-3. However, it is desirable that the temperature at the visible moisture front be estimated as closely as possible for accurate operation. Tests are in progress to develop estimates of temperature at the visible moisture front from air temperature, wind, a roughness coefficient, and solar radiation.

DEFINITION OF TERMS

ADC	Diffusion coefficient for the layer approximately halfway between the evaporation front and the surface to make sure it is diffusing through the dry soil.
AGRAD	Water vapor driving gradient from moisture front to the surface.
AIST	Distance from middle of Kth layer to the surface in centimeters when 1-cm-thick layers are used.
BD	Array for the bulk density of each soil layer.
CATM	Water vapor concentration of atmosphere in grams per cubic centimeter of air.
CCOEF	Energy-mass coupling coefficient.
COUPL	Array of the part of thermal vapor transfer due to the energy-mass coupling for each soil layer.
DCONST	Array of water vapor diffusion coefficient in soil for each soil layer. Computed in real function routine listed at end of program.
EVAPJ	Evaporation flux in grams per second.
FICKS	Array of the part of thermal vapor transfer due to Fick's law for each soil layer.
FVAPOR	Water flux in grams per second due to temperature gradient.
GRADC	Water vapor concentration of atmosphere in grams per cubic centimeter of air per centimeter of distance.
GRADLT	Gradient of the log of the temperature.
IP	The number of 1-cm layers in which the soil profile is divided.
IT	The total number of time periods for the model to run.
L	The first L in MOIST is k/2; it is used to select a dry layer that is over the evaporation front. The second L is a DO loop subscript.
QCOND	Array of the amount of water transferred out of each soil layer in the form of liquid water.
QCONDD	Array for each soil layer of the liquid water transferred down.
QCONDU	Array for each soil layer of the liquid water transferred up.
QEVAP	Array of the quantity of evaporated moisture.
QVAPOR	Water vapor transfer due to temperature gradient per soil layer (array).
RH	The relative humidity of the atmospheric air during the time period.
SAVE	Evaporation from moisture front.
SAVE1	Distance in centimeters from the surface of the soil to the moisture front of the soil.
SEC	The number of seconds in each time period.

SWITCH	Allow moisture to evaporate from the layer with moisture front in it.
T	Array for the temperature of each soil layer during the time period.
TA	The temperature of the atmosphere air during the time period.
TCK	Array of temperature converted to Kelvin for each soil layer.
VWC	Array of volumetric water content for each soil layer in cubic centimeters of water per cubic centimeter of soil.
WATER	Array of moisture level of each soil layer in grams of water per cubic centimeter of soil.
WC	Array for water content of each soil layer (dry-weight basis). Example: 6%, read in as 0.06.
WDIFF	Diffusivity coefficient for a particular soil.

INPUT/OUTPUT

Input

Program inputs read in as data are arranged in the following order and formats:

1. IP, IT, and SEC on one card in I10, I10, and F10.0 format.
2. BD array (bulk density of each soil layer) arranged in 15F5.0 format.
3. WC array (initial moisture content at each soil layer) arranged also in 15F5.0 format.
4. RH, TA, and T (RH and TA are single variables and T is an array) arranged in F3.0, F2.0, and 15F5.0 format.

The maximum number of soil layers is 15. If a deeper profile is needed, enlarge the dimension statement and the input and output formats.

Output

The output of the program consists of the time period, the moisture content of each level for that time period, the distance from the surface to the center of the soil layer with the moisture front, and the quantity of evaporated moisture. The output variables are J, (WC(I), I=1, IP), SAVE1, and SAVE, formated as I5, 15F7.4, F5.2, and E15.6.

PROGRAM SETUP AND EXECUTION

MOIST is written in FORTRAN G, a standardized FORTRAN supported by IBM, for the IBM 370/165 computer. The program does not use any special system functions, but is easily transformable to any FORTRAN compiler. The standard code for an IBM 370/165 is EBCDIC, and the cards were punched on an IBM 029 keypunch.

The card deck is arranged in the following sequence:

A. Control cards
   1. Job card
   2. // EXEC FTGCLG
   3. //C.SYSIN DD *

B. Main program deck

C. Function

D. Control cards
   1. /*
   2. //G.SYSIN DD *

E. Data

F. Control cards
   1. /*
   2. //

The // EXEC FTGCLG card in the control section tells the computer to compile, link and execute the program. The //C.SYSIN DD * card causes the program and the function to be compiled. All initializing of values to zero should be done in the program. All linkage to execute a FORTRAN program is then compiled. The //G.SYSIN DD * card then causes the program to be executed using the following data cards. The compiled program uses approximately 5,000 memory locations, and the execution requires 30,000 memory locations on the IBM 370/165. To simulate 4 days, the computer compile and execution times are approximately 2.0 and 5.0 seconds, respectively.

PROGRAM LISTING

```
C       THIS PROGRAM CALCULATES DISTRIBUTION OF MOISTURE DURING THE
C      ORYING STAGE
       DIMENSION BD(15), WC(15), T(16), C(16), WATER(15), QEVAP(15),
      1QVAPOR(16),QCOND(16),DCONST(15),QCONDU(16),QCONDD(15),VWC(15),
      1FICKS(15),COUPL(15),TCK(I6)
       REAO(1,51)IP, IT, SEC
       REAO(1,52)(BD(I),I=1,IP)
       REAO(1,53)(WC(I),I=1,IP)
   51 FORMAT(2I10,F10.0)
   52 FORMAT(15F5.0)
   54 FORMAT(F3.0, F2.0, 15F5.0)
   53 FORMAT(15F5.0)
   27 FORMAT(' TIME  WC(1)  WC(2)  WC(3)  WC(4   WC(5)  WC(6)  WC(7)  WC
      1(8)  WC(9) WC(10) WC(11) WC12) WC(13) WC(14) WC(15)  OIST  QEVAP')
       WRITE(3,27)
       DO 125 M=1,1P
  125 VWC(M) =  WC(M) * BO(M)
       DO 75 J=1,IT
       READ(1,54) RH,TA, (T(I),I=1,IP)
       T(16) =T(15)
       DO 75  J2=1,4
       SWITCH=0
       OO 1 K=1,16
    1 C(K)= 2.288E-6*10**((T(K)-3)/76)
C      MOISTURE TRANSFER OUE TO TEMPERATURE GRAOIENTS SECTION
       DO 90  K=1,IP
       DCONST(K)= O(T(K), 8O(K), WC(K))
C      THIS STATEMENT SKIPS MOISTURE TRANSFER IF MOISTURE CONTENT IS
C      LESS THAN 1%.
       IF(WC(K).LE.0.018)  GO TO 105
       CCOEF =(-0.0000067 + 0.000384*WC(K))/ 18
       GRAOC =C(K)- C(K+1)
       TCK(K)=5*(T(K)-32)/9+273
       TCK(K+1)=5*(T(K+1)-32)/9+273
       GRAOLT=ALOG(TCK(K)/TCK(K+1))
       FICKS(K)=DCONST(K)*GRAOC
       COUPL(K)=CCOEF*GRADLT
       FVAPOR=FICKS(K)+COUPL(K)
       QVAPOR(K) = FVAPOR * SEC
       QVAPOR(K) = A8S(QVAPOR(K))
       GO TO 110
  105 QVAPOR(K) = 0
  110 CONTINUE
C      EVAPORATION SECTION
C      THIS STATEEMENT BYPASSES EVAPORATION STEP IF MOISTURE CONTENT
C       IS LESS THAN 0.5%
       IF(WC(K).LE.0.005) GO TO 80
C          THIS STATEMENT BYPASSES EVAPORATION STEP IF EVAPORATION HAS BEEN
C      CALCULATED FOR A HIGHER SLICE
       IF(SWITCH.EQ.1) GO TO BO
       CATM = 2.288E-6 * 10**((TA-3)/76)*RH
       DIST=K-0.5
       SAVE1 = DIST
       AGRAO=(C(K)- CATM)/ DIST
       L=K/2
       IF(L.LE.1) L= 1
       ADC=OCONST(L)
       EVAPJ = ADC*AGRAD
       QEVAP(K) = EVAPJ * SEC
       QEVAP(K) = ABS(QEVAP(K))
       SAVE = QEVAP(K)
       SWITCH=1
```

PROGRAM LISTING—Continued

```
      GO TO 70
   80 QEVAP(K) = 0
      L=0
      DIST=0
      AGRAD=0
      ADC=0
      EVAPJ=0
C     THIS SECTION COMPUTES WATER TRANSFERRED DUE TO HYDRAULIC CONDUCTIVITY
70    IF(VWC(K).LE.0.02) GO TO 480
      IF(VWC(K).LE.0.055) GO TO 135
      WDIFF=(10**((VWC(K) - 0.046) / 0.036))* 0.00001
      GO TO 91
  135 WDIFF = 1.55E-5
      GO TO 91
480   WDIFF=0.0
   91 IF(K.EQ. 1) GO TO 11
      IF(WC(K) -WC(K-1)) 11,11,12
   12 QCONDU(K) = WDIFF * (VWC(K) - VWC(K-1)) * SEC
      GO TO 15
   11 QCONDU(K) = 0
   15 IF(K.EQ.15) GO TO 13
      IF(WC(K) - WC(K+1)) 13,13,14
   14 QCONDD(K) = WDIFF * ( VWC(K) - VWC(K+1)) * SEC
      GO TO 16
   13 QCONDD(K) = 0
   16 QCONDU (16)=0
   90 CONTINUE
430   DO 18 N=1,15
      IF(N .EQ. 1) GO TO 17
      QCOND(N) = -QCONDD(N) - QCONDU(N) +QCONDU(N+1) + QCONDD(N-1)
      GO TO 18
   17 QCOND(N) = - QCONDD(N) + QCONDU(N+1)
   18 CONTINUE
      DO 65 L=1,15
      WATER(L) = WC(L)*BD(L)
      IF(T(L) - T(L+1))45,40,40
   40 IF(L.EQ.1) GO TO 100
      WATER(L) = WATER(L) - QEVAP(L) - QVAPOR(L) + QCOND(L)+ QVAPOR(L-1)
      GO TO 50
  100 WATER(L) = WATER(L) - QEVAP(L) - QVAPOR(L) + QCOND(L)
      GO TO 50
   45 WATER(L) = WATER(L) - QEVAP(L)+QCOND(L)- QVAPOR(L)
     1+ QVAPOR(L+1)
   50 IF(WATER(L).LE.0)  WATER(L) = 0
      WC(L) = WATER(L)/BD(L)
      VWC(L) = WATER(L)
   65 CONTINUE
      WC(15) =  WC(14) + WC(14) - WC(13)
   75 WRITE(3,26) J, WC(1), WC(2), WC(3), WC(4), WC(5), WC(6), WC(7),
     1WC(8), WC(9), WC(10), WC(11), WC(12), WC(13), WC(14), WC(15),
     1SAVE1,SAVE
   26 FORMAT(I5,15F7.4,F5.2,E15.6)
      RETURN
      END
      REAL FUNCTION D(T, BD, WC)
      TK =T+460
      E=0.286*((TK/492)**1.75)
      F=BD/2.65 + (WC*BD)
      F1=1.0-F-0.23
      D=E*F1
      RETURN
      END
```

EXAMPLE RUN
Input Data

For read statement	Field 1	Field 2	Field 3	Field 4	Field 5	...	Field 14	Field 15	Field 16	Field 17
Read (1,51) IP,IT,SEC	15	79	900			...				
Read (1,52) (BD (I),I=1,IP)	1.08	1.08	1.08	1.08	1.08	...	1.3	1.3		
Read (1,53) (WC (I),I=1,IP)	0.0703	0.0703	0.0703	0.0703	0.0703	...	0.0703	0.0703		
	RH	TA	T (1)	T (2)	T (3)	...	T (12)	T (13)	T (14)	T (15)
Read (1,54) RH,TA, (T (I),I=1,IP)	0.28	74	58	58	58	...	60	61	61	61
	0.28	73	61	60	60	...	60	61	62	63
	0.22	81	68	68	67	...	64	64	64	65

Output Data

```
          $DATA
TIME   WC(1)  WC(2)  WC(3)  WC(4)  WC(5)  WC(6)  WC(7)  WC(8)  WC(9) WC(10) WC(11) WC12) WC(13) WC(14) WC(15)  DIST   QEVAP
   1 0.0693 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.50   0.106599E-02
   1 0.0684 0.0702 0.0703 0.0702 0.0712 0.0696 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.50   0.106996E-02
   1 0.0675 0.0701 0.0703 0.0703 0.0720 0.0690 0.0702 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.50   0.107370E-02
   1 0.0667 0.0700 0.0703 0.0704 0.0727 0.0686 0.0700 0.0702 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.50   0.107724E-02
   2 0.0656 0.0698 0.0703 0.0705 0.0732 0.0682 0.0698 0.0702 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.50   0.130920E-02
   2 0.0646 0.0696 0.0703 0.0707 0.0737 0.0679 0.0696 0.0702 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0702 0.50   0.131430E-02
   2 0.0637 0.0694 0.0702 0.0709 0.0741 0.0676 0.0694 0.0701 0.0703 0.0703 0.0703 0.0703 0.0703 0.0703 0.0702 0.50   0.131917E-02
   2 0.0627 0.0692 0.0702 0.0711 0.0744 0.0674 0.0692 0.0701 0.0703 0.0703 0.0703 0.0703 0.0703 0.0702 0.0702 0.50   0.132385E-02
   3 0.0613 0.0688 0.0702 0.0713 0.0748 0.0672 0.0691 0.0700 0.0702 0.0703 0.0703 0.0703 0.0703 0.0702 0.0702 0.50   0.189652E-02
   3 0.0600 0.0685 0.0702 0.0715 0.0751 0.0671 0.0690 0.0699 0.0702 0.0703 0.0703 0.0703 0.0703 0.0702 0.0702 0.50   0.190620E-02
   3 0.0587 0.0681 0.0702 0.0717 0.0753 0.0669 0.0688 0.0698 0.0702 0.0703 0.0703 0.0703 0.0703 0.0702 0.0701 0.50   0.191559E-02
   3 0.0574 0.0677 0.0702 0.0718 0.0755 0.0668 0.0687 0.0697 0.0701 0.0703 0.0703 0.0703 0.0703 0.0702 0.0701 0.50   0.192475E-02
   4 0.0554 0.0673 0.0701 0.0721 0.0757 0.0667 0.0686 0.0696 0.0701 0.0702 0.0702 0.0703 0.0702 0.0702 0.0702 0.50   0.252650E-02
   4 0.0535 0.0670 0.0700 0.0723 0.0759 0.0667 0.0685 0.0695 0.0701 0.0702 0.0702 0.0703 0.0702 0.0702 0.0702 0.50   0.254434E-02
   4 0.0516 0.0665 0.0699 0.0724 0.0760 0.0666 0.0684 0.0694 0.0700 0.0702 0.0702 0.0702 0.0702 0.0702 0.0703 0.50   0.256170E-02
   4 0.0498 0.0661 0.0699 0.0726 0.0762 0.0665 0.0683 0.0693 0.0700 0.0702 0.0701 0.0702 0.0702 0.0703 0.0703 0.50   0.257868E-02
   5 0.0472 0.0655 0.0698 0.0728 0.0763 0.0665 0.0682 0.0692 0.0699 0.0701 0.0702 0.0702 0.0702 0.0703 0.0703 0.50   0.351497E-02
   5 0.0447 0.0649 0.0697 0.0730 0.0764 0.0664 0.0682 0.0692 0.0699 0.0701 0.0702 0.0702 0.0703 0.0703 0.0703 0.50   0.354667E-02
   5 0.0421 0.0643 0.0696 0.0731 0.0765 0.0663 0.0681 0.0691 0.0698 0.0700 0.0701 0.0702 0.0703 0.0703 0.0702 0.50   0.357800E-02
   5 0.0396 0.0636 0.0695 0.0732 0.0766 0.0663 0.0680 0.0690 0.0698 0.0700 0.0701 0.0702 0.0703 0.0703 0.0702 0.50   0.360910E-02
   6 0.0363 0.0630 0.0694 0.0733 0.0768 0.0662 0.0679 0.0690 0.0697 0.0700 0.0702 0.0702 0.0703 0.0702 0.0702 0.50   0.448423E-02
   6 0.0330 0.0623 0.0693 0.0733 0.0769 0.0662 0.0679 0.0690 0.0696 0.0700 0.0702 0.0702 0.0703 0.0702 0.0702 0.50   0.453430E-02
   6 0.0297 0.0616 0.0691 0.0734 0.0770 0.0662 0.0678 0.0689 0.0696 0.0699 0.0702 0.0702 0.0703 0.0702 0.0701 0.50   0.458422E-02
   6 0.0264 0.0609 0.0690 0.0734 0.0771 0.0661 0.0678 0.0688 0.0695 0.0699 0.0701 0.0702 0.0703 0.0702 0.0701 0.50   0.463413E-02
   7 0.0221 0.0603 0.0688 0.0735 0.0771 0.0662 0.0677 0.0688 0.0695 0.0699 0.0701 0.0701 0.0703 0.0702 0.0701 0.50   0.569379E-02
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   7 0.0135 0.0587 0.0685 0.0735 0.0772 0.0662 0.0676 0.0687 0.0694 0.0698 0.0701 0.0701 0.0703 0.0701 0.0700 0.50   0.585458E-02
   7 0.0092 0.0579 0.0683 0.0735 0.0772 0.0662 0.0676 0.0686 0.0694 0.0698 0.0700 0.0701 0.0703 0.0701 0.0700 0.50   0.593185E-02
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   8 0.0053 0.0540 0.0678 0.0735 0.0772 0.0661 0.0676 0.0686 0.0693 0.0697 0.0700 0.0702 0.0703 0.0701 0.0699 1.50   0.222132E-02
   8 0.0000 0.0536 0.0675 0.0734 0.0773 0.0661 0.0676 0.0685 0.0692 0.0696 0.0700 0.0702 0.0703 0.0701 0.0699 0.50   0.713343E-02
   8 0.0010 0.0510 0.0672 0.0734 0.0773 0.0661 0.0676 0.0685 0.0692 0.0696 0.0700 0.0702 0.0702 0.0701 0.0699 1.50   0.224794E-02
   9 0.0018 0.0485 0.0668 0.0733 0.0772 0.0662 0.0675 0.0685 0.0691 0.0696 0.0699 0.0703 0.0702 0.0701 0.0700 1.50   0.242349E-02
   9 0.0025 0.0463 0.0663 0.0733 0.0772 0.0662 0.0675 0.0684 0.0691 0.0696 0.0699 0.0703 0.0701 0.0701 0.0700 1.50   0.241768E-02
   9 0.0031 0.0442 0.0659 0.0731 0.0771 0.0663 0.0674 0.0684 0.0690 0.0696 0.0698 0.0703 0.0701 0.0701 0.0700 1.50   0.241296E-02
   9 0.0037 0.0422 0.0654 0.0730 0.0771 0.0663 0.0674 0.0684 0.0690 0.0696 0.0698 0.0703 0.0701 0.0701 0.0700 1.50   0.240853E-02
  10 0.0042 0.0401 0.0649 0.0729 0.0771 0.0662 0.0674 0.0683 0.0690 0.0696 0.0698 0.0702 0.0701 0.0701 0.0700 1.50   0.244928E-02
  10 0.0047 0.0382 0.0644 0.0727 0.0771 0.0662 0.0674 0.0683 0.0689 0.0696 0.0698 0.0702 0.0701 0.0701 0.0700 1.50   0.244532E-02
  10 0.0052 0.0363 0.0638 0.0726 0.0771 0.0662 0.0674 0.0683 0.0689 0.0695 0.0698 0.0701 0.0701 0.0701 0.0701 1.50   0.244162E-02
  10 0.0000 0.0368 0.0633 0.0724 0.0771 0.0661 0.0673 0.0682 0.0689 0.0695 0.0698 0.0701 0.0701 0.0701 0.0701 0.50   0.784429E-02
  11 0.0005 0.0353 0.0629 0.0723 0.0770 0.0660 0.0673 0.0683 0.0688 0.0695 0.0698 0.0701 0.0702 0.0701 0.0701 1.50   0.202971E-02
  11 0.0010 0.0338 0.0625 0.0721 0.0769 0.0659 0.0672 0.0683 0.0688 0.0694 0.0697 0.0700 0.0702 0.0702 0.0701 1.50   0.202660E-02
  11 0.0015 0.0324 0.0621 0.0719 0.0769 0.0659 0.0672 0.0683 0.0688 0.0694 0.0697 0.0700 0.0702 0.0702 0.0702 1.50   0.202367E-02
  11 0.0019 0.0311 0.0616 0.0717 0.0768 0.0658 0.0671 0.0683 0.0688 0.0693 0.0697 0.0700 0.0702 0.0702 0.0702 1.50   0.202090E-02
  12 0.0023 0.0302 0.0612 0.0715 0.0765 0.0658 0.0671 0.0682 0.0688 0.0693 0.0696 0.0700 0.0702 0.0702 0.0702 1.50   0.163955E-02
  12 0.0027 0.0293 0.0608 0.0713 0.0763 0.0658 0.0670 0.0681 0.0688 0.0693 0.0696 0.0700 0.0701 0.0702 0.0703 1.50   0.163755E-02
  12 0.0031 0.0284 0.0604 0.0711 0.0761 0.0658 0.0670 0.0681 0.0688 0.0693 0.0696 0.0700 0.0701 0.0702 0.0703 1.50   0.163564E-02
  12 0.0034 0.0275 0.0601 0.0709 0.0759 0.0658 0.0670 0.0680 0.0687 0.0692 0.0696 0.0700 0.0701 0.0702 0.0703 1.50   0.163382E-02
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  13 0.0041 0.0262 0.0594 0.0704 0.0756 0.0657 0.0669 0.0680 0.0686 0.0692 0.0695 0.0699 0.0702 0.0703 0.0704 1.50   0.138854E-02
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14 0.0050 0.0245 0.0584 0.0698 0.0752 0.0654 0.0669 0.0679 0.0686 0.0691 0.0695 0.0698 0.0701 0.0703 0.0705 1.50     0.114205E-02
14 0.0052 0.0241 0.0581 0.0697 0.0750 0.0653 0.0668 0.0678 0.0686 0.0691 0.0695 0.0698 0.0701 0.0703 0.0705 1.50     0.114107E-02
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15 0.0033 0.0234 0.0571 0.0690 0.0744 0.0650 0.0667 0.0677 0.0684 0.0690 0.0694 0.0698 0.0701 0.0703 0.0706 1.50     0.100374E-02
15 0.0036 0.0231 0.0569 0.0688 0.0743 0.0650 0.0666 0.0677 0.0684 0.0690 0.0694 0.0698 0.0701 0.0703 0.0705 1.50     0.100287E-02
15 0.0039 0.0227 0.0567 0.0687 0.0742 0.0649 0.0665 0.0676 0.0683 0.0690 0.0693 0.0698 0.0701 0.0703 0.0705 1.50     0.100202E-02
16 0.0042 0.0224 0.0566 0.0684 0.0741 0.0648 0.0665 0.0676 0.0683 0.0690 0.0694 0.0697 0.0701 0.0703 0.0705 1.50     0.916429E-03
16 0.0044 0.0221 0.0564 0.0682 0.0740 0.0648 0.0664 0.0675 0.0683 0.0690 0.0694 0.0697 0.0701 0.0703 0.0705 1.50     0.915705E-03
16 0.0047 0.0218 0.0562 0.0680 0.0739 0.0647 0.0664 0.0675 0.0683 0.0690 0.0694 0.0697 0.0701 0.0703 0.0704 1.50     0.915003E-03
16 0.0049 0.0215 0.0560 0.0678 0.0738 0.0647 0.0663 0.0675 0.0682 0.0689 0.0693 0.0697 0.0701 0.0703 0.0704 1.50     0.914322E-03
17 0.0051 0.0213 0.0558 0.0676 0.0737 0.0646 0.0663 0.0674 0.0682 0.0689 0.0694 0.0697 0.0701 0.0703 0.0704 1.50     0.871972E-03
17 0.0029 0.0218 0.0557 0.0674 0.0736 0.0645 0.0662 0.0674 0.0682 0.0688 0.0694 0.0697 0.0701 0.0702 0.0704 0.50     0.261408E-02
17 0.0032 0.0215 0.0555 0.0673 0.0735 0.0645 0.0662 0.0674 0.0682 0.0688 0.0694 0.0697 0.0701 0.0702 0.0704 1.50     0.877151E-03
17 0.0035 0.0212 0.0553 0.0671 0.0734 0.0644 0.0661 0.0673 0.0682 0.0688 0.0693 0.0697 0.0700 0.0702 0.0704 1.50     0.876457E-03
18 0.0037 0.0209 0.0552 0.0670 0.0732 0.0643 0.0661 0.0673 0.0681 0.0688 0.0693 0.0697 0.0700 0.0702 0.0704 1.50     0.835330E-03
18 0.0039 0.0206 0.0550 0.0668 0.0731 0.0643 0.0660 0.0672 0.0681 0.0688 0.0692 0.0697 0.0700 0.0702 0.0704 1.50     0.834709E-03
18 0.0042 0.0203 0.0548 0.0667 0.0730 0.0642 0.0660 0.0672 0.0681 0.0687 0.0692 0.0697 0.0700 0.0702 0.0703 1.50     0.834107E-03
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19 0.0048 0.0195 0.0543 0.0663 0.0727 0.0640 0.0658 0.0671 0.0680 0.0687 0.0692 0.0696 0.0700 0.0702 0.0703 1.50     0.832406E-03
19 0.0050 0.0192 0.0541 0.0662 0.0726 0.0640 0.0658 0.0671 0.0680 0.0686 0.0692 0.0696 0.0700 0.0702 0.0703 1.50     0.831875E-03
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20 0.0036 0.0187 0.0534 0.0658 0.0722 0.0638 0.0656 0.0669 0.0679 0.0686 0.0691 0.0695 0.0699 0.0701 0.0703 1.50     0.835510E-03
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21 0.0038 0.0182 0.0530 0.0655 0.0720 0.0636 0.0655 0.0668 0.0678 0.0685 0.0690 0.0694 0.0699 0.0701 0.0703 1.50     0.834429E-03
21 0.0038 0.0180 0.0529 0.0654 0.0719 0.0635 0.0654 0.0668 0.0678 0.0685 0.0690 0.0694 0.0699 0.0701 0.0703 1.50     0.834429E-03
21 0.0038 0.0179 0.0527 0.0653 0.0718 0.0635 0.0654 0.0667 0.0677 0.0685 0.0690 0.0694 0.0699 0.0701 0.0704 1.50     0.834429E-03
22 0.0038 0.0179 0.0526 0.0651 0.0718 0.0634 0.0654 0.0667 0.0677 0.0684 0.0690 0.0694 0.0698 0.0701 0.0704 1.50     0.693277E-03
22 0.0038 0.0179 0.0525 0.0649 0.0717 0.0634 0.0653 0.0667 0.0677 0.0684 0.0690 0.0694 0.0698 0.0701 0.0704 1.50     0.693277E-03
22 0.0038 0.0179 0.0524 0.0648 0.0716 0.0633 0.0653 0.0666 0.0676 0.0683 0.0690 0.0694 0.0698 0.0701 0.0704 1.50     0.693277E-03
22 0.0038 0.0178 0.0523 0.0646 0.0716 0.0633 0.0652 0.0666 0.0676 0.0683 0.0690 0.0694 0.0698 0.0701 0.0704 1.50     0.693277E-03
23 0.0038 0.0178 0.0522 0.0645 0.0715 0.0632 0.0652 0.0666 0.0676 0.0683 0.0690 0.0694 0.0698 0.0701 0.0704 1.50     0.708998E-03
23 0.0038 0.0177 0.0521 0.0644 0.0714 0.0632 0.0651 0.0665 0.0675 0.0683 0.0690 0.0694 0.0698 0.0701 0.0704 1.50     0.708998E-03
23 0.0038 0.0177 0.0520 0.0643 0.0714 0.0632 0.0651 0.0665 0.0675 0.0683 0.0690 0.0694 0.0698 0.0701 0.0704 1.50     0.708998E-03
23 0.0038 0.0176 0.0519 0.0642 0.0713 0.0631 0.0651 0.0665 0.0675 0.0682 0.0689 0.0694 0.0698 0.0701 0.0704 1.50     0.708998E-03
24 0.0038 0.0175 0.0518 0.0640 0.0712 0.0631 0.0650 0.0664 0.0675 0.0682 0.0689 0.0694 0.0697 0.0701 0.0704 1.50     0.708998E-03
24 0.0038 0.0175 0.0517 0.0639 0.0711 0.0630 0.0650 0.0664 0.0674 0.0682 0.0689 0.0694 0.0697 0.0701 0.0704 1.50     0.708998E-03
24 0.0038 0.0174 0.0516 0.0638 0.0711 0.0630 0.0649 0.0664 0.0674 0.0682 0.0689 0.0694 0.0697 0.0700 0.0704 1.50     0.708998E-03
24 0.0038 0.0173 0.0515 0.0637 0.0710 0.0629 0.0649 0.0663 0.0674 0.0681 0.0689 0.0693 0.0697 0.0700 0.0704 1.50     0.708998E-03
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PART 3.—EMERGE: A SIMULATION OF COTTON GERMINATION AND EMERGENCE

By D. F. Wanjura[1]

DESCRIPTION

The following pages contain a short description and detailed instructions for using the computer model of cotton emergence, EMERGE. A comprehensive discussion of the theory and logic utilized in EMERGE is given by Wanjura et al.[2] Validation of EMERGE and its application for studying the sensitivity of cotton emergence to several soil parameters have been documented by Wanjura.[3]

EMERGE simulates the time distribution of cotton seedling emergence. Theoretical equations that describe water absorption by seeds and elongation of the cotton hypocotyl, with accompanying logic, form the basis of the model. Parameter values for the theoretical equations and the logic were derived from experimental data and other observations obtained from emergence tests conducted under controlled environmental conditions. Parameter values in the equations are dependent functions of the soil environment. In this manner the equations reflect the effect of temperature, moisture, and physical impedance of the soil on the emerging seedlings

Cotton emergence is divided into two phases in EMERGE. Within each phase the average performance of a population of emerging seedlings is described. The first phase is germination, which is followed by the second phase, called emergence. Germination extends from the time of planting until the average radicle length reaches 3 mm. Germination progress is related to water absorption rate, which is dependent on soil temperature and moisture. Water absorption rate increases between 60° and 100° F, but is assumed to stop below 60° F and level off above 100° F. Germination (or 3-mm radicle length) is considered to have occurred when the moisture content of the seed exceeds a specific level for a given temperature and soil moisture. These specific seed-moisture levels were determined from empirical data.

Emergence begins with the completion of germination and depends on soil temperature, moisture, and physical impedance. Emergence progress is related to the average hypocotyl elongation of the seedling population. The temperature limits for hypocotyl elongation are 60° and 104° F. Temperatures outside this range are assumed to stop or interrupt hypocotyl elongation.

Seedling emergence is calculated from a set of regression equations. These equations were developed from experimental data relating average hypocotyl length and soil-moisture level to the percentage of seedlings which exceed certain specific lengths. In the model, the specific lengths represent planting depths. For example, if the hypocotyl elongation portion of the model indicates average hypocotyl length as 4 cm, with a planting depth of 3.8 cm, and if the percentage of seedlings equal to or greater than 3.8 cm in length is 50%, as calculated with the appropriate regression equation, then 50% emergence has occurred from a 3.8-cm planting depth. Percentage emergence, of course, would be lower if the planting depth was greater for the same average hypocotyl length.

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[2] Wanjura, D. F., Buxton, D. R., and Stapleton, H. N. 1973. A model for describing cotton growth during emergence. Trans. ASAE (Am. Soc. Agric. Eng.) 16: 227–231.

[3] Wanjura, D. F. 1973. Effect of physical soil properties on cotton emergence: Prediction and quantitative description. U.S. Dep. Agric. Tech. Bull. No. 1481, 20 pp.

LIMITATIONS

The temperature range of EMERGE extends from 60° to 104° F. Soil temperatures are measured hourly at seed level.

Soil-moisture tension can vary from 0.33 to 11 bars. Soil moisture should be sampled in the interval including seed depth ±0.64 cm at least every 2 days. When the soil dries to seed depth after germination, soil moisture should then be sampled in the zone where the seedling radicle is absorbing moisture from the soil.

Soil physical impedance is the input parameter most difficult to describe numerically. The values used in developing EMERGE were measurements made in soil that was uniformly compacted from seed level to the soil surface. Even though the same type of soil penetrometer (0.4-cm-diameter blunt end) is used both in the field and in the laboratory, the same physical impedance reading on the penetrometer could represent different magnitudes of soil resistance to seedling emergence. Rarely in the field is the physical impedance level in the soil uniformly distributed with depth. The permissible range of physical impedance values for the covering soil over the seed is 3.3 to 50 lb/in^2 (PI in program). Physical impedance should be measured by inserting the penetrometer 2.5 cm into the covering soil over the seed drill. Measurements should be taken at least every 2 days

Planting depth designations are limited to 1.25-cm increments between 1.3 and 7.5 cm. If the depth of soil over the seed changes after planting, the time of change and the amount must be reflected in the computer coding of EMERGE where planting depth (DEPTH) is specified.

There is no algorithm in EMERGE to describe changes in seed vigor that may occur after planting. Thus, if long periods of adverse temperature or saturated soil are encountered, EMERGE may produce an inaccurate simulation because seed germination percentage has changed. The model was developed from experimental data on acid-delinted seed; however, it should be suitable for situations where fuzzy seed is planted.

Henry D. Bowen and James W. Jones at North Carolina State University suggest the following modification of EMERGE. The present method of calculating the limits of hypocotyl elongation (EST) for a low-temperature period followed by a warm period predicts lower growth rates than observed. If EST is calculated by using a running average, the accuracy for the above conditions is improved. At the same time, the accuracy under normal warming conditions is not affected. North Carolina has programed EMERGE for IBM 360 FORTRAN with the option of EST being calculated with or without using a running average.

DEFINITION OF TERMS

A	Array of hourly seed-level soil temperatures in degrees Fahrenheit.
CLOK	Counter for accumulating time in hours.
DE	Hypocotyl elongation during 1 hour, in centimeters.
DELMOS	Seed-moisture increase during the hour preceding germination.
DEPTH	Planting depth in centimeters.
DT	Array for storing the calculated hourly fractional accumulated increments of growing time prior to printing as output.
DWATER	Hourly increase in seed moisture in percent, dry weight.
EL	Array for storing accumulated hypocotyl lengths in centimeters prior to printing as output.
ELONG	Accumulated length of hypocotyl in centimeters.
ELST	Accumulated hypocotyl length in centimeters.
EM	Array for storing hourly EST values prior to printing as output.
EP	Array for storing cumulative percentage emergence values prior to printing as output.
EST	A three-dimensional array of maximum hypocotyl lengths used to calculate hypocotyl elongation.
GERMT	Elapsed time from planting when germination occurs in hours.
GP	Standard seed germination in percent.
IDATE	Date of test.
J	Counter for accumulating time in hours.
KL	Parameter used in calculating rate of seed-moisture uptake.
KNL	Array for storing hourly KT values prior to printing as output.
KT	A three-dimensional array of rate of elongation parameter values used to calculate hypocotyl elongation.
M	Seed-level soil-moisture tension in bars.

MOIST	Subroutine in which time variation of seed-level soil moisture is specified.
NDEPTH	Integer value of DEPTH.
PI	Soil physical impedance in pounds per square inch.
PLACE	Variable for identifying location of test.
S	TEMP.
TEMP	Seed-level soil temperature in degrees Celsius.
TIM	Time in hours.
TIME	Array for storing time values in hours prior to printing as output.
TMAX	Total allowable emergence time for the soil environmental conditions existing during the hour.
TWATER	Accumulated seed moisture in percent, dry weight.
TWATERL	Parameter for temporarily storing the value of accumulated seed moisture in percent, dry weight.

INPUT/OUTPUT

Input

Program inputs read in as data are arranged in the following order and formats:

1. A table of KT values is read under 5F 10.0 format. These data are included with the source deck, which can be obtained from the author. The KT values do not appear in the output section.

2. A table of EST values is read under 5F 10.0 format. These data are also included with the source deck and do not appear in the output section.

The following data must appear in sequence after input 2 and be supplied by the user:

3. PLACE, M, PI, IDATE, DEPTH, and GP on one card in A10, F5.0, F5.0, 5X, A10, and 2F5.2 format.

4. A-array (hourly seed-level soil temperatures) arranged in 16F5.0 format on each card. The last card should have 9999. punched in the first five spaces. The number of hours simulated is equal to the number of A-array values. A maximum of 500 values may be specified.

The following information is required input, but does not appear in the data section of the program deck; necessary changes must be made directly in the main program.

5. The variation of seed-level soil moisture (M) over time is specified in subroutine MOIST. This information must be supplied by the user in FORTRAN statements.

6. Physical impedance (PI) variation over time is specified in the main program where indicated by comment cards. The change in physical impedance must be described by the user in FORTRAN statements.

Output

The first information printed out is identifying data for the simulation, including location, beginning seed-level soil moisture, initial soil physical impedance, and date. This information is printed under the format of statement 31.

During germination the parameters CLOK, TEMP, M, KL, DWATER, DELMOS, and TWATER are printed hourly in 7F10.5 format.

When seed germination is reached this is printed under the format of statement 52—GERMINATION TIME EQUALS "F5.0."

During the emergence phase of EMERGE, hourly values of TIME, A, DE, EL, KNL, EM, DT, and EP are printed according to the format of statement 34.

PROGRAM SETUP AND EXECUTION

EMERGE is programed in FORTRAN for a CDC 6400 computer.

EMERGE does not use any special system functions that are peculiar to a CDC 6400. Some variable names are seven characters long, which is a greater word length than most other computers allow. The CDC 6400 also permits the "A format" specification to be a maximum of A (10).

The standard code read by a CDC 6400 is BCD. Computers which have EBCDIC as the standard code may not read cards punched with BCD code. Normally, computers can read either code, provided an appropriate control card is utilized.

The card deck is arranged in the following sequence:

A. Control cards
   1. Job card
   2. RUN (S)
   3. SETCORE
   4. LGO
   End-of-record card: Multiple-punch 7-8-9 in card column 1

B. Main program deck

C. Subroutines

End-of-record card: Multiple-punch 7-8-9 in card column 1

D. Data

End-of-file card: Multiple punch 6-7-8-9 in card column 1

The RUN (S) card in the control card section causes the computer to compile EMERGE. All memory locations in the computer are zeroed by the SETCORE card. The LGO card causes the program to be executed. In addition to the initializing accomplished by the LGO card, some variables are initially set equal to zero in the main program. However, for the control cards indicated for running on a CDC 6400, initializing within the main program is redundant. To compile EMERGE requires 10,112 memory locations. Program execution uses 9,984 memory locations. Computer compilation and execution time required to simulate a 10-day emergence period is approximately 5.2 seconds of central processor time.

PROGRAM LISTING

```
              PROGRAM EMERGE(INPUT,OUTPUT,TAPE1=INPUT)

        C******SECTIONS SUBJECT TO CHANGE FOR SIMULATION ARE AS FOLLOWS****

        C******(1)  MOISTURE, BARS-- THIS IS IN A SUBROUTINE
        C******(2)  PHYSICAL IMPEDANCE, PSI

000003        DIMENSION KT(6,4,5), EST(6,4,5)
000003        DIMENSION A(500), DF(500), TIME(500), EL(500),
             1KNL(500), EM(500), EP(500), DT(500)
000003        REAL M,K,KNL,KL
000003        READ70,(((KT(I,J,L),L=1,5),J=1,4),I=1,6)
000030        PRINT 88
000034        READ 70,(((EST(I,J,L),L=1,5),J=1,4),I=1,6)
000061     20 READ 30, PLACE, M, PI, IDATE, DEPTH, GP
000101        PRINT 31, PLACE, M, PI, IDATE
000115      1 PRINT 40
000121     70 FORMAT(5F10.0)
000121     88 FORMAT(2H//)
000121     40 FORMAT(///,5X,*TIME*,6X,*TEMP*,5X,*MOS*,8X,*KL*,6X,
             1*DWATER*,5X,*DELMOS*,3X,*TWATER*/)
000121     50 FORMAT(16F5.0)
000121     51 FORMAT(7F10.5)
000121     52 FORMAT(//10X,*GERMINATION TIME EQUALS*,F5.0,2X,*HOURS*//)
000121     30 FORMAT(A10,F5.0,F5.0,5X,A10,2F5.2)
000121     31 FORMAT(1H1,20X,*LOCATION:*,1X,A10,3X,*MOISTURE:*,F5.2,
             13X,*PHYSICAL IMPEDANCE:*,F5.1,3X,*DATE:*,1X,A10//)
000121        GD= GP/100.

        C**** INITIALIZATION OF PARAMETERS

000123        TWATERL=0.
000124        DWATER=0.
000125        CLOK= 0.
000126        GERMT= 0.
000127        ELONG=0.
000130        CLOK= 0.
000131        DT(J) = 0.
000134        ELST= .05
000136        EL(J)= 0.
000141        ELONG= 0.
000142        PI= 3.3
000143     60 J=0
000144    500 READ 50,(A(I), I= 1,500)
000157        IF(EOF,1)61,500

        C**** THIS SECTION COMPUTES THE 3-MM RADICLE EMERGENCE EVENT
        C**** BY SIMULATING THE IMBIBITIONAL WATER UPTAKE OF COTTON
        C**** SEED.  THE INPUTS ARE HOURLY SOIL TEMPERATURE F, AND
        C**** SOIL MOISTURE IN BARS.

000162     61 J=J+1
000164        CALL MOIST(M, CLOK)
000166        IF(A(J).GT.100.) A(J)= 100.
000175        TEMP=(A(J)-32.)*.55555555
```

PROGRAM LISTING—Continued

```
000203          CLOK= CLOK + 1.
000205          IF(TEMP.LT.15.55555) GO TO 15
000210          IF(TEMP.GE.32.22220) GO TO 89
000213          IF(TEMP.GE.15.55555) GO TO 90
000216       89 KL= -.05171368 + .000149960*(TEMP**2.) + .0343398B*M
               1 - .0006448513*(M  **2.) - .0009024209*TEMP*M
000236          GO TO 91
000236       90 KL= .0337762 + .0000855456*TEMP**2. - .0034T882*M
000247       91 DWATER=KL*(80.0 - TWATERL)
000253          IF((TEMP.GE.26.66).AND.(TEMP.LT.32.2)) GO TO 63
000265          IF(TEMP.GT.32.2) GO TO 66
000270          IF((TEMP.GT.21.2).AND.(TEMP.LT.26.66)) GO TO 65
000302          IF((TEMP.LE.21.2).AND.(TEMP.GE.15.55)) GO TO 62
000315       62 DELMOS=-.1133196 + .000705254*(TEMP**2.) -.00134777B*
               1M   + .001177446*(M  **2.)
000333          GO TO 64
000333       63 DELMOS= -.6954544 + .001961955*(TEMP**2.) + .0833515*
               1M   + .007626679*(M  **2.) - .006411228*M  *TEMP
000353          GO TO 64
000353       65 DELMOS= -.3583704 + .001383181*(TEMP**2.) -.03509194*
               1M   + .003506748*(M  **2.)
000371          GO TO 64
000371       66 DELMOS= 3.392908 - .0019702?*(TEMP**2.) - .3693547*M
               1  + .008647528*(M  **2.) + .007306203*TEMP*M
000411       64 IF(DWATER.LT.DELMOS)GO TO 10
000414          TWATER= TWATERL + DWATER
000416          GO TO 16
000417       15 KL=0.0
000420          DWATER=0.0
000421          DELMOS=0.0
000422          TWATER=TWATERL
000424       16 PRINT 51,CLOK, TEMP, M,   KL, DWATER, DELMOS, TWATER
000446          TWATERL=TWATER
000450          GO TO 61
000450       10 TWATER=TWATERL + DWATER
000452          PRINT 51,CLOK, TEMP, M,   KL, DWATER, DELMOS, TWATER
000474          GERMT= CLOK
000476          PRINT 52, GERMT
000503          DWATEP=0.
000504          TWATERL=0.
000505          GO TO 502

       C**** THIS SECTION CALCULATES HYPOCOTYL ELONGATION IN CM
       C**** USING HOURLY INPUTS OF SOIL TEMPERATURE F, SOIL
       C**** MOISTURE IN BARS, AND PHYSICAL IMPEDANCE IN PSI

000506      502 KKK= GERMT
000510          KN= KKK + 1
000512          J= KKK
000513          TIM= J
000514       22 FORMAT(  1X,*TIME*,2X,*TEMPERATURE*,5X,*DF*,9X,
               1*ELONGATION*,13X,*KNL*,12X,*EMAXT*, 6X,*OTIME*, 4X,*EMPERCENT*)
000514       34 FORMAT( 1X,F4.0,5X,F4.0,7X,F5.3,8X,F7.3,10X,F15.10,5X
               1,F5.2,7X,F6.5,3X,F5.1)
000514       73 J= J + 1
000516          TIM= TIM + 1.
```

PROGRAM LISTING—Continued

```
000520           T= A(J)
000523           IF(T.GT. 999.) GO TO 501
000526           IF((T.LT.60.).OR.(T.GT.104.)) GO TO 46

       C**** PHYSICAL IMPEDANCE IS INCREASED WHEN AVERAGE HYPOCOTYL LENGTH
       C**** EQUALS PLANTING DEPTH.  IN CALIBRATING THE MODEL, IT WAS
       C**** FOUND THAT THE FIELD MEASURED PI VALUES EXPRESSED IN PSI SHOULD
       C**** BE DIVIDED BY 10.  THE LOWEST PERMISSIBLE PI VALUE IS 3.3.  IN
       C**** GENERAL PI VALUES OF 6, 12, AND 20 ARE REPRESENTATIVE OF LIGHT,
       C**** MEDIUM, AND SEVERE SOIL PHYSICAL IMPEDANCES.

000541           IF(FLONG.GE.DEPTH)GO TO 144
000544           GO TO 145

       C$$$$ PI IS DESCRIBED IN STATEMENT 144

000545       144 IF((TIM.GE.195.).AND.(TIM.LT.243.))PI=6.3-.054*(TIM-195.)
000563           IF((TIM.GE.243.).AND.(TIM.LT.338.))PI=3.7-.0178*(TIM-243.)
000601           IF(TIM.GE.338.)PI=4.5
000605           IF(PI.LT.3.3)PI=3.3
000611       145 CALL MOIST(M,TIM)
000613           KNL(J) = K(T,M,PI,KY)
000622           EM(J) = K(T,M,PI,EST)
000631           DE(J)= KNL(J)*ELST*(EM(J) - ELST)
000643           S= (T - 32)*.555555
000647           IF(S.LT.21.1111) GO TO 74
000652           IF((S.GE.21.1111).AND.(S.LE.32.2222)) GO TO 75
000665           IF(S.GT.32.2222) GO TO 92
000670        74 CON=.202744E-06
000672           TMAX=492.999 -CON*EXP(S) - 17.6902*M - 1.50139*(M**2)
                1+ 2.76729*M
000707           GO TO 93
000710        75 CON=.836166E-12
000712           TMAX=471.445 - 13.6641*S + CON*EXP(S) + 62.4350*M
                1- 2.35855*(M**2) - .548660*S*M
000732           GO TO 93
000732        92 TMAX=82.8845+96.9449*M-2.25039*(M**2)-1.69967*S*M
000745        93 DT(J)= 1.0/TMAX + DT(J-1)
000754           IF(EM(J).LT.ELST) GO TO 47
000761           EL(J)= EL(J-1) + DE(J)

       C**** THIS SECTION COMPUTES PERCENTAGE EMERGENCE FROM THE AVERAGE
       C**** HYPOCOTYL LENGTH(EL(J)

000771           IF(FLONG.LT.1.0) GO TO 252

       C$$$$ THIS SECTION CALCULATES THE STATEMENT NUMBER OF THE EQUATION
       C$$$$ TO BE USED IN CALCULATING PERCENTAGE EMERGENCE. THE CORRECT
       C$$$$ EQUATION DEPENDS ON PLANTING DEPTH.

000774           IF(DEPTH.LT.1.875)GO TO 1000
000777           IF(DEPTH.GE.6.875)GO TO 1001
001002           NDEPTH=(DEPTH/1.25) + .5
001006           GO TO 1002
001007      1000 NDEPTH=1
001011           GO TO 1002
```

PROGRAM LISTING—Continued

```
001011     1001 NDEPTH=6
001013     1002 GO TO(200,201,202,203,204,205),NDEPTH

        C        APPLICABLE RANGE OF ELONG IS 1.0 - 4.8 CM.  DEPTH= 1.3 CM
001025      200 EP(J)=48.4553*ELONG - 6.62388*(ELONG**2) + .239116*(ELONG**3) - .8
               126568*ELONG*M
001046          GO TO 250
        C        APPLICABLE RANGE OF ELONG IS 1.0 - 5.6 CM.    DEPTH = 2.5 CM
001047      201 IF((ELONG.LT.1.0).OR.(ELONG.GT.6.7)) GO TO 250
001062          EP(J)=   -22.8372*ELONG + 24.9413*(ELONG**2) - 3.81217*(ELONG**3)
               1+  .0204049*(ELONG**5)
001105          GO TO 250
        C        APPLICABLE RANGE OF ELONG IS 1.0 - 6.6 CM.    DEPTH= 3.8 CM
001106      202 IF((ELONG.LT.1.4).OR.(ELONG.GT.6.6))GO TO 250
001121          EP(J)=  4.34967*M-12.9137*ELONG+7.47138*(ELONG**2)-.0123471*(E
               1LONG**5) - 2.06569*ELONG*M
001144          GO TO 250
        C        APPLICABLE RANGE OF ELONG IS 1.0 - 7.5 CM.    DEPTH= 5.0 CM
001145      203 EP(J)=-11.6959*ELONG + 5.09969*(ELONG**2) - .0354686*(ELONG**4) +
               11.37004*(M**2) - 1.3153*ELONG*M
001173          GO TO 250
        C        APPLICABLE RANGE OF ELONG IS 1.0 - 7.5 CM.   DEPTH= 6.3CM
001174      204 EP(J)=-12.0228*M + 13.1315*ELONG - 8.56872*(ELONG**2) + 1.61419*(E
               1LONG**3) - .00985923*(ELONG**5) + 3.11801*(M**2) + .992038*ELONG*M
001231          GO TO 250
        C        APPLICABLE RANGE OF ELONG IS 2.4 - 7.5 CM.   DEPTH= 7.5 CM
001232      205 IF((ELONG.LT.3.5).OR.(ELONG.GT.7.5)) GO TO 250
001245          EP(J)=-8.48373*M + 5.0013*ELONG - 1.53460*(ELONG**3) + .438285*(EL
               1ONG**4) - .0303805*(ELONG**5) + 2.0752*(M**2) + .813498*ELONG*M
001302      250 EP(J)= EP(J)*GD
001307          IF(EP(J).LT.EP(J-1)) EP(J)= EP(J-1)
001322      252 ELST= DE(J) + ELST
001326          ELONG= EL(J)
001331          TIME(J)= TIM
001334          GO TO 73
001335       46 DE(J)= 0.
001340          KNL(J)= 0.
001343          EM(J)= 0.
001346          TIME(J)= TIM
001351          EL(J)= EL(J-1)
001356          DT(J)= DT(J-1)
001363          EP(J)= EP(J-1)
001370          GO TO 73
001371       47 DE(J)= 0.
001374          TIME(J)= TIM
001377          EL(J)= EL(J-1)
001404          EP(J)= EP(J-1)
001411          GO TO 73
001412      501 PRINT 22
001416          PRINT 34,(TIME(I), A(I), DE(I), EL(I), KNL(I), EM(I), DT(I), EP(I)
               1,I=KN,J)
001457          STOP
001461          END

                SUBROUTINE MOIST(M, TCLOK)

        C**** THE SECTION  BELOW EXPRESSES THE MOISTURE IN THE SEED ZONE AS A
        C**** FUNCTION OF TIME FOR A PARTICULAR FIELD TEST
```

PROGRAM LISTING—Continued

```
000006           REAL M
000006           IF(TCLOK.LT.122.)M=.9
000011           IF((TCLOK.GE.122.).AND.(TCLOK.LT.168.))M=.9+.0108*(TCLOK-122.)
000027           IF((TCLOK.GE.168.).AND.(TCLOK.LT.216.))M=1.4
000042           IF((TCLOK.GE.216.).AND.(TCLOK.LT.289.))M=1.4+.0137*(TCLOK-216.)
000060           IF((TCLOK.GE.289.).AND.(TCLOK.LT.338.))M=2.4+.0122*(TCLOK-289.)
000076           IF(TCLOK.GE.338.)M=3.
000102           RFTURN
000103           END


                REAL FUNCTION K(T,M,PT,KT)

          C**** THIS FUNCTION CALCULATES THF VALUE OF EMAXT AND KNL FOR HYPOCOTYL
          C**** ELONGATTON AS A FUNCTTON OF TEMPERATURE F, MOTSTURE IN BARS, AND
          C**** PHYSICAL TMPEDANCF TN PSI BY USTNG LINEAR INTERPOLATION IN TWO OR
          C**** THRFE DTMFNSIONS

000011           DTMENSION TA(6),MA(4),PTA(5)
000011           DTMENSION KT(6,4,5)
000011           REAL MA,KT,M,KL,KU,KSUB
000011           DATA TA/60.0,70.0,80.0,90.0,100.0,104.0/,MA/0.33,3.0,
                110.0,11.0/,PIA/3,3,16.0,32.0,48.0,50.0/
000011           ITL=ITU=0
000013           DO 1 I=1,6
000014           IF(T.GE.TA(I)) GO TO 1
000020           ITL=I-1
000072           ITU=I
000023           GO TO 3
000024         1 CONTINUF
000026         3 DT=(T-TA(ITL))/(TA(ITU)-TA(ITL))
000041           IF(DT.EQ.0.) ITU=ITL
000043           IMU=IML=0
000045           DO 2 I=1,4
000047           IF(M.GE.MA(I)) GO TO 2
000053           IML=I-1
000055           IMU=I
000056           GO TO 4
000057         2 CONTINUF
000061         4 DM=(M-MA(IML))/(MA(IMU)-MA(IML))
000074           IF(DM.EQ.0.) IMU=IML
000076           IPL=IPU=0
000100           DO 5 I=1,5
000102           IF(PI.GE.PIA(I)) GO TO 5
000106           IPL=I-1
000110           IPU=I
000111           GO TO 6
000112         5 CONTINUF
000114         6 DP=(PT-PIA(IPL))/(PIA(IPU)-PIA(IPL))
000127           IF(DP.EQ.0.) IPU=IPL
000131           D=SQRT(DP**2. + DM**2. + DT**2.)
000151           KL=KT(ITL,IML,IPL)
000162           KU=KT(ITU,IMU,IPU)
000171        11 IF((DT.GT.0.).AND.(DM.GT.0.)) GO TO 12
000203           IF((DT.GT.0.).AND.(DP.GT.0.)) GO TO 13

          C      CALCULATION OF K WHEN MOISTURF AND PHYSICAL IMPEDANCE ARE
          C      BETWEFN TABLE VALUES
```

PROGRAM LISTING—Continued

```
000215        9 K=D*(KU-KL) + KL
000222          GO TO 10

         C      CALCULATIONS TO FIND PROPER VALUE OF K WHEN TEMPERATURE AND
         C      MOISTURE ARE BETWEEN TABLE VALUES

000222       12 IF(DP.GT.0.) GO TO 14


000225          DIFML=(MA(IML)-M)/(MA(IML)- MA(IMU))
000240          SUBL1= (DIFML)*(KT(ITL,IML,IPL) - KT(ITL,IMU,IPL))
000255          SUBL2= KT(ITL,IML,IPL) - SUBL1
000265          DIFMU= (MA(IML) - M)/(MA(IML) -MA(IMU))
000300          SUBU1= (DIFMU)*(KT(ITU,IML,IPL) - KT(ITU,IMU,IPL))
000315          SUBU2= KT(ITU,IML,IPL) - SUBU1
000325          KSUB=((SUBU2-SUBL2)*(TA(ITU)-T))/(TA(ITU)-TA(ITL))
000344          K= SUBU2 - KSUB
000346          GO TO 10

         C      CALCULATIONS OF K WHEN TEMPERATURE AND PHYSICAL IMPEDANCE ARE
         C      BETWEEN TABLE VALUES

000346       13 IF(DM.GT.0.) GO TO 14
000351          DIFML=(PIA(IPL)-PI)/(PIA(IPL) - PIA(IPU))
000364          SUBL1= (DIFML)*(KT(ITL,IML,IPL) - KT(ITL,IML,IPU))
000401          SUBL2= KT(ITL,IML,IPL) - SUBL1
000411          DIFMU= (PIA(IPL) - PI)/(PIA(IPL) - PIA(IPU))
000424          SUBU1= (DIFMU)*(KT(ITU,IML,IPL) - KT(ITU,IML,IPU))
000441          SUBU2= KT(ITU,IML,IPL) - SUBU1
000451          KSUB=((SUBU2-SUBL2)*(TA(ITU)-T))/(TA(ITU) - TA(ITL))
000470          K= SUBU2 - KSUB
000472          GO TO 10
000472       15 IF(DT.GT.0.) GO TO 14
000475          DIFML= (MA(IML) - M)/(MA(IML) - MA(IMU))
000510          SUBL1= (DIFML)*(KT(ITL,IML,IPL) - KT(ITL,IMU,IPL))
000525          SUBL2= KT(ITL,IML,IPL) - SUBL1
000535          DIFMU= DIFML
000536          SUBU1= (DIFMU)*(KT(ITL,IML,IPU) - KT(ITL,IMU,IPU))
000553          SUBU2= KT(ITL,IML,IPU) - SUBU1
000563          KSUB= ((SUBU2 - SUBL2)*(PIA(IPU) - PI))/(PIA(IPU) - PIA(IPL))
000602          K= SUBU2 - KSUB
000604          GO TO 10

         C      CALCULATION OF K WHEN TEMPERATURE, MOISTURE, AND PHYSICAL
         C      IMPEDANCE ARE BETWEEN TABLE VALUES

000604       14 DIFSQ= SQRT(DM**2 + DP**2)
000620          SUBL1= DIFSQ*(KT(ITL,IML,IPL)- KT(ITL,IMU,IPU))
000640          SUBL2= KT(ITL,IML,IPL) - SUBL1
000650          SUBU1= DIFSQ*(KT(ITU,IML,IPL) - KT(ITU,IMU,IPU))
000665          SUBU2= KT(ITU,IML,IPL) - SUBU1
000675          KSUB= ((SUBU2 - SUBL2)*(TA(ITU) - T))/(TA(ITU)- TA(ITL))
000714          K= SUBU2 - KSUB
000716       10 RETURN
000720          END
```

EXAMPLE RUN

Input Data

TABLE OF KT VALUES

```
.00480832 .010383691.0139927  .0192581
.00852267.013597265.0162947   .0199945
.0113208  .00705326           .0102575

.00501412 .013159308.0187783  .0200439
.00469919 .00920764 .0172229  .0198467
.0113818  .0138237  .0133494

.00788747 .0128454  .0152562  .0252810
.00444414 .007950115.0190638  .0252810
.00557594 .0122496  .0226051  .0431408

.008331856.015699449.0271838  .0485776
.00050000 .00975761 .0198626  .0263540
.00651485 .0162866  .0562627

.00898465 .0149086  .0330927  .0629105
.058517036.0435381
.0000000  .000000   .000000   .0000000
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TABLE OF EST VALUES

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2.75      1.25       .85       .55
1.65       .75       .55       .35
 .75       .25       .15       .25

7.85      3.05      1.65      1.35
4.95      2.85      1.45       .95
1.15       .75       .35       .15

8.25      3.55      2.35      1.55
6.25      3.50      1.55      1.05
2.95       .65       .35       .25

9.85      4.15      2.25      1.25
7.55      2.95      1.55       .65
3.55      1.05       .35

7.05      2.75      1.55       .75
 .45       .25
0.00      0.00      0.00      0.00
```

PLACE M PI IDATE DEPTH GP

```
LUBBOCK     1.0  3.3      4-28-71     5.0089.00
```

SEED-LEVEL TEMPERATURES

```
  69   68   69   69   69   68   67   65   64   62   61   60   59   58   57   56
  55   54   54   55   58   62   68   72   75   78   79   79   78   76   74   71
  69   67   66   65   64   63   62   62   61   61   61   61   65   68   72   75
  80   83   84   84   82   81   78   74   72   71   69   67   67   65   63   63
  61   60   60   62   63   67   71   74   76   79   80   80   79   78   76   74
  72   70   68   67   66   64   64   62   61   61   61   62   65   68   74   76
  80   82   83   83   82   81   78   76   74   73   71   70   69   68   67   66
  65   64   63   64   65   68   71   74   76   79   80   81   80   79   77   75
  73   72   71   70   69   68   67   66   65   65   65   66   68   70   74   77
  79   80   80   80   79   78   77   76   75   74   73   72   71   69   68   66
  64   63   63   64   66   68   72   75   77   79   80   80   79   78   76   74
  73   71   69   68   66   65   64   63   62   61   61   63   66   67   71   76
  79   81   82   80   79   78   77   74   72   70   70   68   67   65   65   64
  64   63   63   64   66   68   71   76   78   82   84   84   84   82   80   77
  75   73   71   70   69   68   67   66   65   65   64   65   65   66   67   68
  71   73   73   73   72   71   69   68   67   66   66   65   65   65   65   65
  65   65   66   67   69   72   71   77   79   80   81   80   79   77   75   72
  71   68   67   67   64   63   63   62   61   61   63   66   68   72   74   80
  81   82   83   82   81   79   76   73   73   73   71   70   69   68   67   66
  65   64   64   64   66   68   70   72   73   73   74   75   73   73   71   69
  68   68   66   65   64   63   62   62   61   60   60   61   63   65   67   69
  72   74   76   76   76   76   74   73   69   66   65   63   62   60   58   57
  57   55   54   54   57   63   65   70   74   77   80   81   82   81   79   76
  74   71   69   68   66   65   63   62   60   60   58   59   60   65   69   71
  76   79   80   81   81   79   78   74   72   71   70   68   67   66   66   65
9999.
```

Output Data

```
LOCATION: LUBBOCK  MOISTURE: 1.00  PHYSICAL IMPEDANCE: 3.3  DATE: 4-28-71

    TIME        TEMP       MOB         KL        DWATER      DELMOB     TWATER

  1.00000   20.55556    .90000     .06679     5.34327     .18441     5.34327
  2.00000   20.00000    .90000     .06486     4.84250     .16852    10.18577
  3.00000   20.55556    .90000     .06679     4.66296     .18441    14.84873
  4.00000   20.55556    .90000     .06679     4.35151     .18441    19.20024
  5.00000   20.55556    .90000     .06679     4.06087     .18441    23.26111
  6.00000   20.00000    .90000     .06486     3.68028     .16852    26.94139
  7.00000   19.44444    .90000     .06299     3.34210     .15307    30.28350
  8.00000   18.33333    .90000     .05940     2.95307     .12346    33.23656
  9.00000   17.77778    .90000     .05768     2.69740     .10932    35.93397
 10.00000   16.66667    .90000     .05441     2.39754     .08233    38.33151
 11.00000   16.11111    .90000     .05285     2.20219     .06948    40.53369
 12.00000   15.55556    .90000     .05135     2.02640     .05708    42.56010
 13.00000   15.00000    .90000    0.00000     0.00000    0.00000    42.56010
 14.00000   14.44444    .90000    0.00000     0.00000    0.00000    42.56010
 15.00000   13.88889    .90000    0.00000     0.00000    0.00000    42.56010
 16.00000   13.33333    .90000    0.00000     0.00000    0.00000    42.56010
 17.00000   12.77778    .90000    0.00000     0.00000    0.00000    42.56010
 18.00000   12.22222    .90000    0.00000     0.00000    0.00000    42.56010
 19.00000   12.22222    .90000    0.00000     0.00000    0.00000    42.56010
 20.00000   12.77778    .90000    0.00000     0.00000    0.00000    42.56010
 21.00000   10.44444    .90000    0.00000     0.00000    0.00000    42.56010
 22.00000   16.66667    .90000     .05441     2.03703     .08233    44.59713
 23.00000   20.00000    .90000     .06486     2.29635     .16852    46.89348
 24.00000   22.22222    .90000     .07289     2.41313     .29594    49.30661
 25.00000   23.88889    .90000     .07946     2.43903     .40220    51.74564
 26.00000   25.55556    .90000     .08651     2.44440     .51622    54.19000
 27.00000   26.11111    .90000     .08897     2.29630     .55593    56.48630
 28.00000   26.11111    .90000     .08897     2.09200     .55593    58.57833
 29.00000   25.55556    .90000     .08651     1.85327     .51622    60.43161
 30.00000   24.44444    .90000     .08176     1.59990     .43938    62.03155
 31.00000   23.33333    .90000     .07722     1.38753     .36595    63.41907
 32.00000   21.66667    .90000     .07080     1.17400     .26221    64.59307
 33.00000   20.55556    .90000     .06679     1.02904     .18441    65.62211
 34.00000   19.44444    .90000     .06299      .90565     .15307    66.52776
 35.00000   18.88889    .90000     .06117      .82006     .13805    67.35182
 36.00000   18.33333    .90000     .05940      .75128     .12346    68.10310
 37.00000   17.77778    .90000     .05768      .68624     .10932    68.78933
 38.00000   17.22222    .90000     .05602      .62800     .09560    69.41734
 39.00000   16.66667    .90000     .05441      .57578     .08233    69.99312
 40.00000   16.66667    .90000     .05441      .54445     .08233    70.53757
 41.00000   16.11111    .90000     .05285      .50009     .06948    71.03766
 42.00000   16.11111    .90000     .05285      .47366     .06948    71.51132
 43.00000   16.11111    .90000     .05285      .44863     .06948    71.95995
 44.00000   16.11111    .90000     .05285      .42492     .06948    72.38487
 45.00000   18.33333    .90000     .05940      .45232     .12346    72.83719
 46.00000   20.00000    .90000     .06486      .46460     .16852    73.30180
 47.00000   22.22222    .90000     .07289      .48823     .29594    73.79003
 48.00000   23.88889    .90000     .07946      .49347     .40220    74.28350
 49.00000   26.66667    .90000     .09148      .52293     .62704    74.80643
           GERMINATION TIME EQUALS    49  HOURS
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Output Data—Continued

```
TIME TEMP   DE   ELONGATION      KNL             EMAXT        DTIME   EMPERCENT
 50   83   .003     .003     .0070046300         8.28        .00797      0.0
 51   84   .003     .006     .0069553809         8.44        .01643      0.0
 52   84   .003     .009     .0069553809         8.44        .02488      0.0
 53   82   .003     .013     .0070538790         8.13        .03240      0.0
 54   81   .004     .016     .0071031280         7.98        .03952      0.0
 55   78   .003     .020     .0067112792         7.70        .04561      0.0
 56   74   .003     .023     .0058290835         7.47        .05073      0.0
 57   72   .003     .025     .0053879856         7.35        .05547      0.0
 58   71   .003     .028     .0051674367         7.29        .06004      0.0
 59   69   .003     .031     .0050086883         6.76        .06330      0.0
 60   67   .002     .033     .0051322893         5.82        .06567      0.0
 61   67   .002     .036     .0051322893         5.82        .06804      0.0
 62   65   .002     .038     .0052558904         4.87        .07022      0.0
 63   63   .002     .040     .0053794914         3.93        .07234      0.0
 64   63   .002     .041     .0053794914         3.93        .07446      0.0
 65   61   .001     .043     .0055030924         2.99        .07656      0.0
 66   60   .001     .044     .0055648930         2.52        .07866      0.0
 67   60   .001     .045     .0055648930         2.52        .08076      0.0
 68   62   .002     .047     .0054412919         3.46        .08286      0.0
 69   63   .002     .049     .0053794914         3.93        .08498      0.0
 70   67   .003     .052     .0051322893         5.82        .08735      0.0
 71   71   .004     .056     .0051674367         7.29        .09192      0.0
 72   74   .005     .060     .0058290835         7.47        .09704      0.0
 73   76   .005     .066     .0062701813         7.59        .10261      0.0
 74   79   .006     .072     .0069318281         7.76        .10901      0.0
 75   80   .007     .078     .0071523771         7.82        .11575      0.0
 76   80   .007     .085     .0071523771         7.82        .12249      0.0
 77   79   .007     .093     .0069318281         7.76        .12890      0.0
 78   78   .007     .100     .0067112792         7.70        .13500      0.0
 79   76   .007     .107     .0062701813         7.59        .14056      0.0
 80   74   .007     .114     .0058290835         7.47        .14568      0.0
 81   72   .006     .120     .0053879856         7.35        .15042      0.0
 82   70   .006     .126     .0049468878         7.23        .15600      0.0
 83   68   .005     .131     .0050704888         6.29        .15863      0.0
 84   67   .005     .136     .0051322893         5.82        .16100      0.0
 85   66   .005     .141     .0051940898         5.34        .16325      0.0
 86   64   .004     .146     .0053176909         4.40        .16539      0.0
 87   64   .004     .150     .0053176909         4.40        .16753      0.0
 88   62   .004     .154     .0054412919         3.46        .16964      0.0
 89   61   .003     .157     .0055030924         2.99        .17174      0.0
 90   61   .003     .160     .0055030924         2.99        .17384      0.0
 91   61   .003     .163     .0055030924         2.99        .17594      0.0
 92   62   .004     .167     .0054412919         3.46        .17805      0.0
 93   65   .005     .172     .0052558904         4.87        .18022      0.0
 94   68   .007     .179     .0050704888         6.29        .18286      0.0
 95   74   .010     .189     .0058290835         7.47        .18798      0.0
 96   76   .011     .200     .0062701813         7.59        .19354      0.0
 97   80   .014     .213     .0071523771         7.82        .20028      0.0
 98   82   .015     .228     .0070538790         8.13        .20781      0.0
 99   83   .016     .243     .0070046300         8.28        .21578      0.0
100   83   .016     .260     .0070046300         8.28        .22375      0.0
101   82   .017     .277     .0070538790         8.13        .23127      0.0
102   81   .018     .295     .0071031280         7.98        .23838      0.0
103   78   .017     .312     .0067112792         7.70        .24448      0.0
```

Output Data—Continued

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104    76    .016    .328    .0062701813    7.59    .25004    0.0
105    74    .016    .344    .0058290835    7.47    .25516    0.0
106    73    .015    .359    .0056085346    7.41    .26008    0.0
107    71    .015    .374    .0051674367    7.29    .26465    0.0
108    70    .014    .388    .0049468878    7.23    .27023    0.0
109    69    .014    .402    .0050086883    6.76    .27309    0.0
110    68    .013    .415    .0050704888    6.29    .27613    0.0
111    67    .013    .428    .0051322893    5.82    .27850    0.0
112    66    .012    .440    .0051940898    5.34    .28074    0.0
113    65    .011    .452    .0052558904    4.87    .28292    0.0
114    64    .010    .462    .0053176909    4.40    .28506    0.0
115    63    .009    .471    .0053794914    3.93    .28718    0.0
116    64    .011    .482    .0053176909    4.40    .28932    0.0
117    65    .012    .494    .0052558904    4.87    .29150    0.0
118    68    .016    .510    .0050704888    6.29    .29413    0.0
119    71    .019    .530    .0051674367    7.29    .29870    0.0
120    74    .023    .553    .0058290835    7.47    .30382    0.0
121    76    .026    .579    .0062701813    7.59    .30938    0.0
122    79    .031    .610    .0069318281    7.76    .31579    0.0
123    80    .034    .644    .0071384490    7.81    .32251    0.0
124    81    .036    .680    .0070717216    7.96    .32957    0.0
125    80    .037    .716    .0071105928    7.80    .33625    0.0
126    79    .037    .753    .0068811775    7.73    .34258    0.0
127    77    .035    .788    .0064400712    7.60    .34832    0.0
128    75    .033    .822    .0060040266    7.47    .35357    0.0
129    73    .031    .853    .0055730436    7.33    .35841    0.0
130    72    .031    .884    .0053575479    7.26    .36306    0.0
131    71    .030    .914    .0051445830    7.19    .36753    0.0
132    70    .029    .943    .0049341490    7.11    .37317    0.0
133    69    .028    .971    .0050118455    6.64    .37646    0.0
134    68    .027    .998    .0050926638    6.16    .37911    0.0
135    67    .025   1.023    .0051766038    5.69    .38150    0.0
136    66    .023   1.047    .0052636657    5.22    .38375    0.0
137    65    .021   1.068    .0053538493    4.75    .38595    0.0
138    65    .022   1.090    .0053603799    4.74    .38814    0.0
139    65    .022   1.112    .0053669105    4.74    .39033    0.0
140    66    .025   1.137    .0052835445    5.19    .39259    0.0
141    68    .030   1.166    .0051055992    6.09    .39525    0.0
142    70    .035   1.201    .0049214103    7.00    .40096    0.0
143    74    .043   1.244    .0056960368    7.25    .40582    0.0
144    77    .050   1.293    .0062678303    7.44    .41131    0.0
145    79    .056   1.349    .0066405871    7.57    .41730    0.0
146    80    .059   1.408    .0068181032    7.63    .42357    0.0
147    80    .061   1.470    .0068041752    7.62    .42982    0.0
148    80    .063   1.532    .0067902471    7.61    .43606    0.0
149    79    .062   1.595    .0065899364    7.54    .44198    0.0
150    78    .061   1.656    .0063921566    7.46    .44763    0.0
151    77    .060   1.716    .0061969076    7.38    .45302    0.0
152    76    .059   1.774    .0060041895    7.30    .45818    0.0
153    75    .057   1.831    .0058140022    7.22    .46312    0.0
154    74    .056   1.887    .0056263457    7.14    .46786    0.0
155    73    .054   1.941    .0054412201    7.06    .47243    0.0
156    72    .052   1.993    .0052586253    6.98    .47682    0.0
157    71    .050   2.044    .0050785614    6.89    .48105    0.0
```

Output Data—Continued

```
158    69    .045   2.088   .0050190210   6.36   .48439    0.0
159    68    .041   2.130   .0051388616   5.91   .48708    0.0
160    66    .033   2.163   .0053829385   5.01   .48936    0.0
161    64    .024   2.187   .0056332590   4.11   .49154    0.0
162    63    .018   2.205   .0057655868   3.66   .49369    0.0
163    63    .018   2.223   .0057752392   3.66   .49585    0.0
164    64    .023   2.247   .0056575335   4.09   .49803    0.0
165    66    .033   2.280   .0054077870   4.97   .50032    0.0
166    68    .042   2.322   .0051517970   5.84   .50301    0.0
167    72    .055   2.378   .0052167735   6.85   .50731    0.0
168    75    .064   2.442   .0056977354   7.07   .51208    0.0
169    77    .071   2.513   .0060216647   7.22   .51725    0.0
170    79    .078   2.591   .0063455941   7.37   .52288    0.0
171    80    .083   2.674   .0065075587   7.45   .52878     .2
172    80    .084   2.757   .0065075587   7.45   .53468    1.0
173    79    .081   2.839   .0063455941   7.37   .54031    1.9
174    78    .079   2.917   .0061836294   7.30   .54571    2.7
175    76    .073   2.990   .0058597001   7.14   .55067    3.6
176    74    .067   3.056   .0055357707   6.99   .55527    4.4
177    73    .064   3.120   .0053738061   6.92   .55970    5.2
178    71    .058   3.178   .0050498768   6.76   .56384    6.0
179    69    .049   3.227   .0050219762   6.25   .56721    6.7
180    68    .043   3.269   .0051560404   5.81   .56990    7.3
181    66    .029   3.299   .0054241686   4.94   .57220    7.9
182    65    .021   3.320   .0055582328   4.50   .57442    8.3
183    64    .013   3.333   .0056922969   4.06   .57660    8.6
184    63    .005   3.338   .0058263610   3.62   .57876    8.8
185    62   0.000   3.338   .0059604252   3.18   .58091    8.8
186    61   0.000   3.338   .0060944893   2.75   .58305    8.8
187    61   0.000   3.338   .0060944893   2.75   .58520    8.8
188    63    .005   3.343   .0058263610   3.62   .58736    8.8
189    66    .028   3.371   .0054201686   4.94   .58965    8.9
190    67    .035   3.406   .0052901045   5.37   .59207    9.3
191    71    .058   3.464   .0050498768   6.76   .59621    9.8
192    76    .075   3.539   .0058597001   7.14   .60118   10.6
193    79    .086   3.625   .0063455941   7.37   .60681   11.6
194    81    .092   3.717   .0063761276   7.60   .61300   12.9
195    82    .094   3.810   .0062446964   7.74   .61950   14.3
196    80    .090   3.901   .0065075587   7.45   .62540   15.7
197    79    .086   3.986   .0063455941   7.37   .63103   17.1
198    78    .081   4.068   .0061836294   7.30   .63602   18.5
199    77    .077   4.145   .0060216647   7.22   .64159   19.8
200    74    .065   4.210   .0055357707   6.99   .64619   21.1
201    72    .057   4.267   .0052118414   6.84   .65047   22.2
202    70    .050   4.317   .0048879121   6.69   .65636   23.2
203    70    .050   4.366   .0048879121   6.69   .66274   24.0
204    68    .032   4.398   .0051560404   5.81   .66494   24.8
205    67    .022   4.420   .0052901045   5.37   .66737   25.4
206    65    .001   4.421   .0055582328   4.50   .66959   25.8
207    65    .001   4.421   .0055582328   4.50   .67181   25.8
208    64   0.000   4.421   .0056922969   4.06   .67399   25.8
209    64   0.000   4.421   .0056922969   4.06   .67617   25.8
210    63   0.000   4.421   .0058263610   3.62   .67834   25.8
211    63   0.000   4.421   .0058263610   3.62   .68050   25.8
```

PART 4.—SIMCOT II: A SIMULATION OF COTTON GROWTH AND YIELD[1]

By J. M. McKinion, D. N. Baker, J. D. Hesketh, and James W. Jones[2]

INTRODUCTION

On the following pages we document a segment of our work in the simulation of cotton growth and yield and provide operating instructions for the resultant computer model SIMCOT II.

This work began as an effort to assess the theoretical yield limits in commercial upland cottons through the calculations of photosynthate production and respiratory losses (*2, 3*)[3] and evolved into an analysis of the physiological reasons for the failure of these cottons to attain this potential. Stapleton (*7*) and Stapleton and Meyers (*9*) had called for the application of systems methodology to this problem for the purpose of design and optimization of machinery arrays, and this work resulted in the first digital-computer simulation of cotton growth (*8*). Similar work was begun independently and at about the same time by A. B. Hearn (*4*) in Uganda.[4]

SIMCOT II is a direct descendent of SIMCOT, which was developed by Duncan (*5*). The overall approach is the same: the calculation of daily production and distribution of photosynthate. The model continues the same philosophy of fruiting, the triggering of abscission of fruit, and delays in node formation in response to physiological stress in the form of carbohydrate shortage, and it continues to limit above-ground vegetative growth relative to root growth in response to moisture stress. Development is still programed in physiological time (a function of temperature).

There are, however, a number of fundamental changes. A plant-map subroutine has been added, which keeps track of the age, weight, and nutritional status of fruit at every node. This provides an interface of insect damage routines. A nitrogen-balance subroutine has been added. Light interception is based on plant height rather than leaf-area index. Height is a useful index of the overall foliage display and is not density dependent as is leaf-area index.

The systems analysis has resulted in other basic changes. We have found that carbohydrate reserves are all available on a temporary basis and (now) may approximate 30% of the dry leaf weight. We have found that only squares (about 12 days old) are abscised in response to carbohydrate stress and only squares within a few days of bloom and very small bolls are abscised in response to nitrogen stress. The most fundamental advance of SIMCOT II lies in the abolition of the "standard plant" as a means of calculating potential growth. The logic replacing the standard plant was essential to the simulation and incorporates the notion of senescence of stem and root tissue. This will be described in detail elsewhere. These changes represent new knowledge about the physiology of cotton, which could not have been obtained through classical reductionist experimental research.

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[1] Cooperative research of Agricultural Research Service and the Mississippi and South Carolina Agricultural Experiment Stations.

[2] Electrical engineer, research agronomist, plant physiologist, and agricultural engineer, Southern Region, Agricultural Research Service, U.S. Department of Agriculture, P.O. Box 5465, Mississippi State, Miss. 39762.

[3] Italic numbers in parentheses refer to items in "Literature Cited," p. 82.

[4] Personal communication, 1970.

VALIDATION

SIMCOT II is essentially a carbohydrate balance. Beginning with emergence, light interception is calculated daily from plant height. From this, photosynthesis is calculated for a unit of ground area. Then, light respiration, maintenance respiration, and growth respiration are calculated and subtracted from photosynthesis to give a net increment of carbohydrate available per plant for growth on that day. Daytime and nighttime increments of growth of roots, stems, leaves, and fruit are calculated separately. The decision as to whether or not to grow leaf and stem tissue is based on estimated plant water stress. All potential growth is based on temperature.

Leaf weights were obtained weekly from large samples of plants grown in State College, Miss., in 1969. From these data a table of daily weight increments was constructed. A drought early in 1969 caused abnormally small leaves. Therefore, to obtain the potential (well-watered) leaf increments needed by SIMCOT II, we multiplied the 1969 data by a factor (LEFADD) to obtain reasonable leaf weights in the simulations (table 4–1). The system's temporary carbohydrate storage capacity is equal to 30 % of the leaf weight. Maximum carryover time is 1 day. Leaf senescence is simulated by subtracting from the leaf weight the increment added 70 days previously.

TABLE 4–1.—*Factors to be used to adjust leaf area production*

Plant population	LAFADD
20,498	1.75
41,000	1.35
80,000	1.00
125,000	1.00

Stem growth was developed as follows: Stem weights from the 1969 weekly plant samples were used to provide potential stem weight increments for the first 42 days of growth. From day 10 to day 42 the growth data fit the following expression:

$$\Delta W = 0.2 + 0.06\,(STMWT), \qquad (4\text{–}1)$$

where ΔW is the potential stem growth and $STMWT$ is the accumulated stem weight in grams.

After 42 days, potential stem growth was obtained from the expression

$$\Delta W = 0.2 + 0.06\,(STMWT - I_{24}), \qquad (4\text{–}2)$$

where ΔW is change in weight in grams per day, $STMWT$ is stem weight in grams, and I_{24} is stem growth 24 days earlier.

Potential root growth is computed in the same way as stem growth, except that it is only 10 % as large and is not affected by moisture stress.

The growth of each fruit is kept track of individually in two-dimensional matrices (one axis representing the main-stem node number and the other axis, the fruiting-branch node number). Temperature effects are accounted for in computing the date of initiation, bloom, and boll opening. Potential weight increments for each fruit are taken from a table of weight increments versus fruit age. The data in that table are taken from fruit grown with an abundant supply of carbohydrates.

The carbohydrate requirements for potential growth of all organs is summed and then divided into the net carbohydrate available. All organ weights are incremented by that fractional amount of their respective potential growth. If the ratio is greater than 1, the excess is stored in temporary reserve. Any excess beyond 30 % of leaf weight is assigned to the stem weight and root weight.

When the first square is 6 days from bloom, a term called BOLINC is computed as the ratio of actual to potential fruit growth. If BOLINC is less than 0.85, stresses are said to exist, which cause the squares to abscise and delay the formation of new nodes, as shown in the flow charts below. All fruit within the appropriate age bracket are shed 8 days from the occurrence of the stress.

The Crops

One crop used to verify our simulation was grown in State College, Miss., in 1961 by Bruce and Römkens (4). Briefly, the treatment they used was as follows: The cotton variety was a doubled haploid, 'Deltapine M8948'. Before planting, fertilizer was broadcast at the rates of 75 lb N, 44 lb P, and 83 lb K per acre. Three side-dressings of 75 lb N each were applied at 4-week intervals after planting. The plants emerged on

May 9 and were uniformly spaced in 91-cm rows at 20,498 plants per acre. The soil was irrigated to field capacity whenever tensiometer readings reached 0.3 bar. Insect control was nearly complete. Ten plants were mapped weekly, and the status of the fruit at each node was recorded. We summarized those data to produce weekly maps of an average or representative plant.

Another crop grown commercially and described by Jenkins et al. (*6*) was planted in 101.6-cm rows at 41,000 plants per acre in 1972 in Copiah County, Miss. At planting, fertilizer was banded at the rates of 20 lb N, 17.5 lb P, and 33 lb K per acre. Some moisture stresses were allowed to occur during the season. Again, insect control was very good. Square and boll counts were made weekly on 30 meters of row.

Results

More detail on these validation experiments can be found in papers by Baker et al. (*1*) and by Jenkins et al (*6*). Main-stem node number and fruiting site production in the 1961 crop are presented in figure 4–1. The data describe a typical sigmoid growth curve. Growth is exponential at first, becoming linear as maintenance respiration becomes significant and leveling off somewhat as carbohydrate shortages brought on by the high demands for boll growth delay the formation of new nodes.

Real and simulated fruit production is presented in figure 4–2. To track square production this well early in the season, the model was programed to abscise pinhead squares (1 day old) in response to solar radiation levels above 700 ly/day. The carbohydrate stresses are mild at first, becoming more severe as the season progresses until some of the bolls mature and open around September 14. Day-to-day variation in the stress was caused by variations in the weather (mainly solar radiation).

Two points should be mentioned here concerning the development of this simulation: First, in order to track properly the early onset of stresses (as evidenced by square shedding and a leveling off of site production in the real system), we had to acknowledge the existence of a large vegetative sink. Numerous mechanisms were tried and coefficients used before we developed equation 4–2. This equation states that potential stem growth is proportional to the weight of the vegetative sink and that tissue no longer contributes to sink strength (capable of cell wall thickening) after 24 days. The second point is that all earlier (unvalidated) versions of SIMCOT were based on the assumption that the fruit is most likely to abscise in response to stress at bloom (about 26 days) and that progressively greater stresses would bracket that, with wider and wider age envelopes of fruit abscised. To accomplish this simulation, we were forced to abandon that assumption in favor of abscission at an earlier age (12 days). Depending on stress intensity then, the present model marks squares 8 to 13 days old, and they are 16 to 21 days old at abscission. Abscission of any bolls ruins the simulation. We believe, therefore, that boll shed results from nitrogen stress.

Figure 4–2 shows apparent regrowth (squares) on the 140th day. We had stopped mapping the real plants before that time, so no data are available to verify this. The model predicts regrowth because the maturing of some bolls made additional photosynthate available for development of new meristems.

The model crop reached a maximum leaf-area index (LAI) of 4.2 on day 95 (August 12) and yielded 2.98 bales per acre.

The computer output for the 1972 Copiah County crop is presented under "Example Runs." This simulation was obtained with the same program as above. The real plants, on the average, and the model plants both produced seven bolls for a yield of 1.68 bales per acre. Again, fruiting was simulated almost perfectly. This crop abscised eight young bolls in response to nitrogen stresses.

We feel that this is a minimal validation effort. SIMCOT II obviously simulates Delta cottons well in the Midsouth. We expect that it will do well in the Southeast and in much of Texas. At present certain modifications are necessary for use on the Texas High Plains and in dryland areas. Generally, these modifications are simple to make and should be considered in the following order:

1. Make sure that the algorithms in PNET for computing plant height and light interception are performing properly for your crop. This has required modification for "okra leafed" cottons and for High Plains varieties.

2. Be sure first square occurs on the proper date. For the High Plains varieties a different

number of physiological days to first square must be used.

3. The WATERZ subroutine is simple. Under dryland conditions modifications in selecting plant water stress levels may be needed.

Weaknesses in the simulation in these areas have pointed to potentially productive future experiments. As new information becomes available, we (and we hope others) will make appropriate modifications in the model.

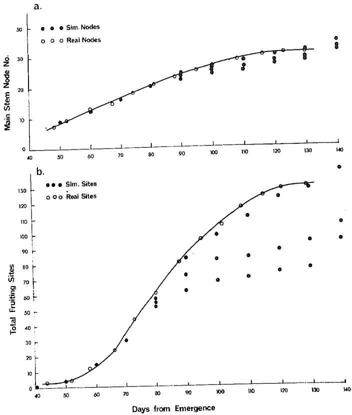


FIGURE 4-1.—A season's time course of main-stem node and fruiting site development. Open circles and lines trace the real crop planted at 20,498 plants per acre. Upper, middle, and lower solid circles represent model predictions for 20,498, 41,000, and 80,000 plants per acre, respectively.

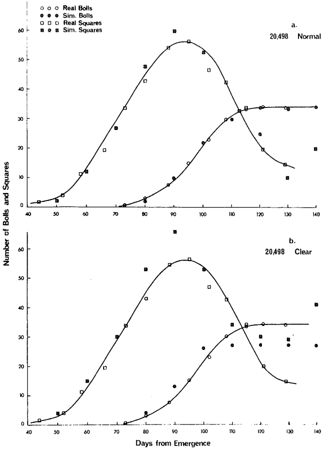
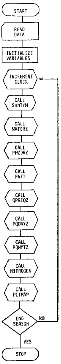


FIGURE 4–2.—Seasonal time course of fruiting for the real crop and for simulated crops at 20,498 plants per acre under normal and all clear skies.

DESCRIPTION AND FLOW CHARTS

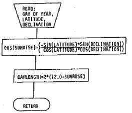
MAIN PROGRAM

THE MAIN PROGRAM INITIALIZES ALL VARIABLES, READS IN WEATHER DATA, PLANT MANAGEMENT DATA AND CALLS ALL SUBROUTINES TO GROW THE PLANT. AFTER THE PLANT HAS BEEN GROWN TO THE END OF THE SEASON, THE MAIN PROGRAM THEN PRINTS PERTINENT INFORMATION: SUCH AS, BALES PER ACRE, NUMBER OF OPEN BOLLS. THE USER CAN CAUSE THE PROGRAM TO LIST THE PLANT MAP AS OFTEN AS DESIRED OR NOT AT ALL. IF THE USER DESIRES, HE CAN ALSO MAKE CHANGES IN THE FRUIT MATRIX TO SIMULATE INSECT DAMAGE.

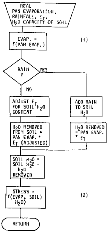


SUBROUTINE SUNTYM

THIS PROGRAM COMPUTES THE LENGTH OF THE DAY FOR ANY DAY OF THE YEAR.


READ:
DAY OF YEAR,
LATITUDE,
DECLINATION
COS(SUNRISE)=(-SIN(LATITUDE)*SIN(DECLINATION))/(COS(LATITUDE)*COS(DECLINATION))
DAYLENGTH=2*(12.0-SUNRISE)
RETURN

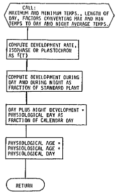
SUBROUTINE WATERZ


REAL
PAN EVAPORATION,
RAINFALL, E_T,
H_2O CAPACITY OF SOIL
EVAP. = f(PAN EVAP.)
(1)
RAIN ?
YES
NO
ADJUST E_T FOR SOIL H_2O CONTENT
ADD RAIN TO SOIL H_2O
H_2O REMOVED FROM SOIL = PAN EVAP. * E_T (ADJUSTED)
H_2O REMOVED = PAN EVAP. * E_T
SOIL H_2O = SOIL H_2O - H_2O REMOVED
STRESS = f(EVAP, SOIL) H_2O)
(2)
RETURN

THIS PROGRAM ADJUSTS SOIL MOISTURE FOR EVAPORATION AND RAINFALL AND EVALUATES PLANT STRESS IN TERMS OF WATER REMAINING IN THE SOIL AND THE PAN EVAPORATION FOR THE DAY, ARBITRARILY. CLIMAT (JJ,4) IS RAINFALL AND CLIMAT (JJ,5) IS PAN EVAPORATION FOR THE JJTH DAY. RUNOFF (OR SOAKTHROUGH) IS CALCULATED. MOISTURE STRESS IS CALCULATED FROM THE COMBINATION OF SOIL WATER CONTENT AND EVAPORATIVE DEMAND AS MEASURED BY PAN EVAPORATION.

(1) AND (2) ARE ARBITRARY RELATIONSHIPS.

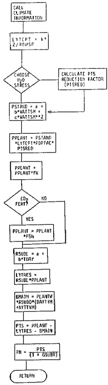
SUBROUTINE PHZOAZ


CALL:
MAXIMUM AND MINIMUM TEMPS., LENGTH OF DAY, FACTORS CONVERTING MAX AND MIN TEMPS TO DAY AND NIGHT AVERAGE TEMPS.
COMPUTE DEVELOPMENT RATE, ISOPHASE OR PLASTOCHRON AS f(T)
COMPUTE DEVELOPMENT DURING DAY AND DURING NIGHT AS FRACTION OF STANDARD PLANT
DAY PLUS NIGHT DEVELOPMENT = PHYSIOLOGICAL DAY AS FRACTION OF CALENDAR DAY
PHYSIOLOGICAL AGE = PHYSIOLOGICAL AGE + PHYSIOLOGICAL DAY
RETURN

THIS PROGRAM CALCULATES THE LENGTH OF EACH PHYSIOLOGICAL DAY AND NIGHT BASED ON THE ESTIMATED AVERAGE TEMPERATURE OF EACH IN °C. One PHYSIOLOGICAL DAY IS A 24 HOUR PERIOD IN WHICH THE AVERAGE TEMPERATURE WAS 26°C. IF THE AVERAGE TEMPERATURE WAS LESS THAN 26°C, THEN WE HAVE A FRACTION OF A PHYSIOLOGICAL DAY. IF THE AVERAGE TEMPERATURE IS GREATER THAN 26°C, THEN WE HAVE A PHYSIOLOGICAL DAY PLUS A FRACTION.

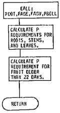
SUBROUTINE PNET

THIS SUBROUTINE CALCULATES THE DAY'S INCREMENT OF NET PHOTOSYNTHATE PRODUCTION PER PLANT. THE FRACTION OF INCIDENT LIGHT INTERCEPTED (LYTCPT) BY THE PLANT CANOPY IS COMPUTED FROM EMPIRICAL DATA BASED ON PLANT HEIGHT (Z). PTSRED IS THE FACTOR BY WHICH LEAF WILTING REDUCES THE RATE OF PHOTOSYNTHESIS. PSTAND IS POTENTIAL GROSS PHOTOSYNTHATE PRODUCTION BY THE PLANT CANOPY BASED ON DAILY TOTAL SOLAR RADIATION (WATTSM). THE POTENTIAL DAY'S GROSS PHOTOSYNTHATE PRODUCTION (PSTAND) IS REDUCED BY THE WATER STRESS FACTOR (PTSRED) AND BY LYTCPT AND FINALLY BY A PLANT POPULATION FACTOR (POPFAC) TO GIVE PHOTOSYNTHATE PRODUCTION ON A PER PLANT BASIS (PPLANT). THIS IS BASED ON EXPERIMENTS IN INTACT CANOPIES AT 300 PPM CO_2. PPLANT IS THEN ADJUSTED FOR AN AVERAGE DAILY CO_2 LEVEL ABOVE 300 IN FIELD AIR. A PROVISION IS MADE FOR FURTHER ADJUSTMENT TO ACCOUNT FOR THE EFFECTS OF CO_2 FERTILIZATION ASSUMING A RELEASE OF 200 LB/ACRE/HR FOR FIVE MIDDAY HOURS. LIGHT RESPIRATION (LYTRES) IS A FUNCTION OF TEMPERATURE AND PROPORTIONAL TO PHOTOSYNTHATE PRODUCTION. MAINTENANCE RESPIRATION IS PROPORTIONAL TO PLANT WEIGHT. GSUBR IS GROWTH RESPIRATION.

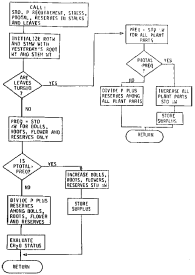

CALL CLIMATE INFORMATION
LYTCPT = k*Z/ROWSP
CHOOSE H2O STRESS
CALCULATE PTS REDUCTION FACTOR (PTSRED)
PSTAND = a + b*WATTSM + c*WATTSM**2
PPLANT = PSTAND *LYTCPT*POPFAC* PTSRED
PPLANT = PPLANT*FN
CO2 FERT?
NO
YES
PPLANT = PPLANT *F5h
RSUBL = a + b*TDAY
LYTRES = RSUBL*PPLANT
BMAIN = PLANTW *RSUBO*(DAYTYM +NYTTYM)
PTS = PPLANT - LYTRES - BMAIN
PN = PTS / (1 + GSUBR)
RETURN

SUBROUTINE QPREQZ

THIS SUBROUTINE CALCULATES THE REQUIRED PHOTOSYNTHATE FOR GROWTH OF EACH PLANT PART: ROOTS, STEMS, LEAVES, AND INDIVIDUAL FRUIT WHICH ARE OLDER THAN 22 DAYS.

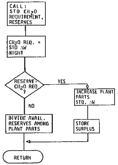

CALL: PCOT,FAGE,FAGV,PBOLL
CALCULATE P REQUIREMENTS FOR ROOTS, STEMS, AND LEAVES.
CALCULATE P REQUIREMENT FOR FRUIT OLDER THAN 22 DAYS.
RETURN

SUBROUTINE PQDAYZ


CALL:
STD. P REQUIREMENT, STRESS, PTOTAL, RESERVES IN STALKS AND LEAVES
INITIALIZE ROTW AND STMW WITH YESTERDAY'S ROOT WT AND STEM WT
ARE LEAVES TURGID ?
YES
NO
PREQ = STD ΔW FOR ALL PLANT PARTS
PTOTAL >PREQ ?
YES
NO
DIVIDE P PLUS RESERVES AMONG ALL PLANT PARTS
INCREASE ALL PLANT PARTS STD ΔW
STORE SURPLUS
RETURN
PREQ = STD ΔW FOR BOLLS, ROOTS, FLOWER AND RESERVES ONLY
IS PTOTAL> PREQ?
YES
NO
INCREASE BOLLS, ROOTS, FLOWERS, RESERVES STD ΔW
STORE SURPLUS
DIVIDE P PLUS RESERVES AMONG BOLLS, ROOTS, FLOWER AND RESERVES
EVALUATE CH2O STATUS
RETURN

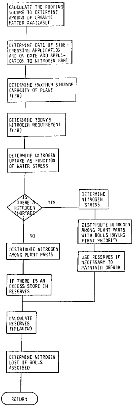
THIS PROGRAM COMPUTES THE PHOTOSYNTHATE USED FOR PLANT GROWTH FOR THE DAY. STMW AND ROTW ARE SET TO TODAYS STEM AND ROOT WEIGHT BEFORE ANY GROWTH OCCURS. THESE TWO VARIABLES ARE THEN USED IN PLTMAP TO RETIRE STEM AND ROOT MATERIAL OLDER THAN 24 DAYS FROM THE RESPIRING BIOMAS. MAXIMUM CH_2O RESERVE SIZE EQUALS 30 PERCENT OF THE LEAF DRY WEIGHT. IT IS ALL AVAILABLE ON ANY GIVEN DAY. PTOTAL = PN + RESERVES. EXCESS PHOTOSYNTHATE BEYOND THAT NEEDED FOR GROWTH AND RESERVES IS ACCUMULATED AS DRY MATTER IN THE ROOTS.

SUBROUTINE PQNYTZ


CALL:
STD CH2O REQUIREMENT, RESERVES
CH2O REQ. = STD ΔW NIGHT
RESERVE> CH2O REQ ?
YES
NO
INCREASE PLANT PARTS STD. ΔW
DIVIDE AVAIL. RESERVES AMONG PLANT PARTS
STORE SURPLUS
RETURN

THIS PROGRAM CALCULATES THE PHOTOSYNTHATE REQUIRED FOR PLANT PARTS FOR THE NIGHT AND COMPUTES THE WEIGHT GAINS EXCEPT FOR FRUIT. IT ALSO COMPUTES WHETHER BOLL SET WILL OCCUR BASED ON THE CALCULATED CARBOHYDRATE STRESS OR LACK OF IT. POLYNA IS THE VARIABLE USED TO DETERMINE BOLL SET AND IT GIVES A VALUE, SIGNALS THAT A BOLL MAY BE SET IF A BLOOM IS PRESENT.

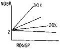
SUBROUTINE NITR


CALCULATE THE ROOTING VOLUME TO DETERMINE AMOUNT OF ORGANIC MATTER AVAILABLE
DETERMINE DATE OF SIDE-DRESSING APPLICATION AND ON DATE ADD APPLICATION TO NITROGEN PART
DETERMINE MAXIMUM STORAGE CAPACITY OF PLANT f(ΔW)
DETERMINE TODAYS NITROGEN REQUIREMENT f(ΔW)
DETERMINE NITROGEN UPTAKE AS FUNCTION OF WATER STRESS
IS THERE A NITROGEN SHORTAGE ?
YES
DETERMINE NITROGEN STRESS
DISTRIBUTE NITROGEN AMONG PLANT PARTS WITH BOLLS HAVING FIRST PRIORITY
USE RESERVES IF NECESSARY TO MAINTAIN GROWTH
NO
DISTRIBUTE NITROGEN AMONG PLANT PARTS
IF THERE IS AN EXCESS STORE IN RESERVES
CALCULATE RESERVES f(PLANTW)
DETERMINE NITROGEN LOST IF BOLLS ABSCISED
RETURN

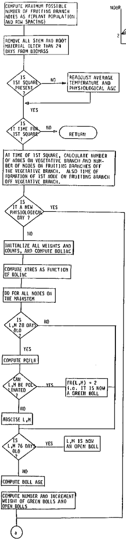
THE NITROGEN SUBROUTINE CALCULATES A NITROGEN BALANCE FOR THE PLANT. NITROGEN REQUIREMENTS FOR STEMS, ROOTS, AND LEAVES ARE CALCULATED AS A FUNCTION OF INCREASE OF WEIGHT OF THE GROWING TISSUES OF THOSE PLANT PARTS. THE SEED AND BURR REQUIREMENTS ARE CALCULATED AS A FUNCTION OF TOTAL FRUIT WEIGHT. NITROGEN UPTAKE IS CALCULATED ON A PLANT BASIS AS A FUNCTION OF WATER STRESS. THIS NITROGEN IS TAKEN FROM A NITROGEN POOL IN THE SOIL THAT CONSISTS OF RESIDUAL NITROGEN FROM THE PREVIOUS YEAR, NITROGEN FROM DECOMPOSITION OF ORGANIC MATTER, AND NITROGEN FROM PRE-EMERGENCE AND SIDEDRESSING APPLICATIONS.

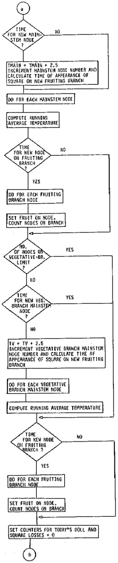
WHEN THE PLANT DEMAND EXCEEDS WHAT CAN BE TAKEN UP DAILY, A NITROGEN STRESS (NSTRES) IS DETERMINED FROM THE SEVERITY OF THE SHORTAGE. IF MORE NITROGEN IS TAKEN UP THAN CAN BE USED, THEN THIS EXCESS NITROGEN IS STORED IN LEAVES, STEMS, AND ROOTS AND THE RESERVE NITROGEN THAT THE PLANT CAN DRAW ON FOR GROWTH IS CALCULATED AS A FUNCTION OF TOTAL STEM, ROOT AND LEAF WEIGHT. THUS WHEN THE PLANT IS IN A SHORTAGE SITUATION IN WHICH THE DEMAND IS MORE THAN SUPPLY OF NITROGEN THAT CAN BE TAKEN UP FROM THE SOIL POOL OF NITROGEN BY THE ROOT SYSTEM, THE PLANT CAN DRAW ON THE RESERVE NITROGEN POOL WHICH CONSISTS OF NITROGEN STORED IN ROOTS, STEMS, AND LEAVES. THUS A COMPLETE NITROGEN BALANCE IS PERFORMED BY THIS SUBROUTINE.

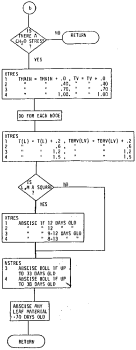
SUBROUTINE PLTMAP



THIS PROGRAM INITIATES SQUARES, MAINSTEM NODES, FRUITING BRANCH INTERNODES, AND A SINGLE VEGETATIVE BRANCH. BOLINC IS COMPUTED BASED ON TODAYS BOLL GROWTH DIVIDED BY THE POTENTIAL GROWTH. CARBOHYDRATE STRESS IS THEN COMPUTED FROM BOLINC. PINHEAD SQUARES ARE ABSCISED IF SOLAR RADIATION IS GREATER THAN 700 WATTS/M^2. DELAYS IN FORMING NEW MAINSTEM NODES AND FRUITING BRANCH INTERNODES ARE GENERATED IF THERE IS A CARBOHYDRATE STRESS. SQUARES OF AN AGE CENTERED AT 12 DAYS ARE ABSCISED IN RESPONSE TO CARBOHYDRATE STRESS ALSO.


COMPUTE MAXIMUM POSSIBLE NUMBER OF FRUITING BRANCH NOTES AS f(PLANT POPULATION AND ROW SPACING)
REMOVE ALL STEM AND ROOT MATERIAL OLDER THAN 24 DAYS FROM BIOMASS
IS 1ST SQUARE PRESENT ?
NO
READJUST AVERAGE TEMPERATURE AND PHYSIOLOGICAL AGE
YES
IS IT TIME FOR 1ST SQUARE ?
NO
RETURN
AT TIME OF 1ST SQUARE, CALCULATE NUMBER OF NODES ON VEGETATIVE BRANCH AND NUMBER OF NODES ON FRUITING BRANCHES OFF THE VEGETATIVE BRANCH. ALSO TIME OF FORMATION OF 1ST NODE ON FRUITING BRANCH OFF VEGETATIVE BRANCH.
IS IT A NEW PHYSIOLOGICAL DAY ?
YES
NO
INITIALIZE ALL WEIGHTS AND COUNTS, AND COMPUTE BOLINC
COMPUTE XTRES AS FUNCTION OF BOLINC
DO FOR ALL NODES ON THE MAINSTEM
IS L,M 28 DAYS OLD ?
NO
YES
COMPUTE PQFLR
CAN L,M BE POLLINATED ?
YES
FR(L,M) = 2 i.e. IT IS NOW A GREEN BOLL
NO
ABSCISE L,M
IS L,M 76 DAYS OLD ?
YES
L,M IS NOW AN OPEN BOLL
NO
COMPUTE BOLL AGE
COMPUTE NUMBER AND INCREMENT WEIGHT OF GREEN BOLLS AND OPEN BOLLS
a


a
TIME FOR NEW MAIN-STEM NODE ?
NO
THAIN = THAIN + 2,5
INCREMENT MAINSTEM NODE NUMBER AND CALCULATE TIME OF APPEARANCE OF SQUARE ON NEW FRUITING BRANCH
DO FOR EACH MAINSTEM NODE
COMPUTE RUNNING AVERAGE TEMPERATURE
TIME FOR NEW NODE ON FRUITING BRANCH ?
NO
YES
DO FOR EACH FRUITING BRANCH NODE
SET FRUIT ON NODE. COUNT NODES ON BRANCH
NO. OF NODES ON VEGETATIVE>BR. LIMIT ?
YES
NO
TIME FOR NEW VEG. BRANCH MAINSTEM NODE ?
YES
NO
TV = TV + 2.5
INCREMENT VEGETATIVE BRANCH MAINSTEM NODE NUMBER AND CALCULATE TIME OF APPEARANCE OF SQUARE ON NEW FRUITING BRANCH
DO FOR EACH VEGETATIVE BRANCH MAINSTEM NODE
COMPUTE RUNNING AVERAGE TEMPERATURE
TIME FOR NEW NODE ON FRUITING BRANCH ?
NO
YES
DO FOR EACH FRUITING BRANCH NODE
SET FRUIT ON NODE, COUNT NODES ON BRANCH
SET COUNTERS FOR TODAY"S BOLL AND SQUARE LOSSES = 0
b


b
IS THERE A CH2O STRESS ?
NO
RETURN
YES
XTRES
1 THAIN = THAIN + .0 , TV = TV + .0
2 " " .40, " " .40
3 " " .70, " " .70
4 " " 1.00, " " 1.00
DO FOR EACH NODE
XTRES
1 T(L) = T(L) + .2 , TBRV(LV) = TBRV(LV) + .2
2 " " .6 , " " .6
3 " " 1.2 , " " 1.2
4 " " 1.5 , " " 1.5
IS L,M A SQUARE ?
NO
YES
XTRES
1 ABSCISE IF 12 DAYS OLD
2 " " 12 " "
3 " " 9-12 DAYS OLD
4 " " 8-13 " "
NSTRES
3 ABSCISE BOLL IF UP TO 33 DAYS OLD
4 ABSCISE BOLL IF UP TO 38 DAYS OLD
ABSCISE ANY LEAF MATERIAL >70 DAYS OLD
RETURN

DEFINITION OF TERMS

Main Program

ADD	Factor used to adjust LAI for different plant populations.
AGE	Counter for real time.
ALAIFC	Leaf area ratio (leaf area/leaf weight).
ATL(3)	Not used.
BALECT	Bales per acre.
BALEFC	Used in determining flowering rate based on plant population.
BLOOM	Number of fruit lost due to bloom sticking.
BOLINC(J)	Percentage of total boll demand, dry weight, added each day. J is time from emergence.
BOLLST	Number of bolls lost on a given day due to carbohydrate shortage.
BOLRES	Boll respiration.
CLIMAT(J,I)	Same as KLYMAT, but used to store weather data that is used in growing season. Julian day changed to day from emergence.
CLIMXX	Variable used to reorder weather data based on days from emergence rather than Julian day.
COSLAT	COS(LATUDE).
COTXX	Weight of mature bolls.
CO2	Carbon dioxide fertilization trigger. Read in with weather data.
DAY	Physiological time. Real variable.
DAYFAC	Factor used in calculating length of daytime physiological time.
DECL (365)	Variable used for calculating daily declination values.
DECLIN(365)	Table of declinations read in.
DIFSUM	Not used.
DMACRE	Number of square decimeters in 1 acre.
EFF	Factor for adjusting photosynthetic efficiency of plant.
ESUBT(I)	Evapotranspiration of plant ESUBT. (I) has five values.
EVAPFC	Maximum transpiration considering pan evaporation.
FAGE(L,M)	Fruitage matrix for main plant.
FAGV(LV,MV)	Age of fruit in days from initiation at proper LV, MV location, vegetation branch.
FLOWER	Used in determining flowering rate based on plant population.
FR(L,M)	Fruiting matrix for main plant.
FRV(LV,MV)	Fruiting matrix where fruit code is stored. LV is vegetative branch main-stem node number. MV is fruiting branch off of vegetative branch node number. FRV(LV, MV) : 1 is square, 2 is green boll, 3 is mature boll, 4 is abscised fruit site, 5 is square designated to abscise, and 6 is boll designated to abscise.
GRCOTX	Weight of green bolls.
GSUBR	Vegetative respiration.
HISTD	Factor used in controlling boll setting.
H2OCAP	Water capacity of soil in inches per one-tenth of rooting depth.
H2OREM	Water remaining in soil.
H2OREX	Water remaining in soil.
H2ORUN	Calculated runoff of rainfall.
I	Physiological time. Integer variable.
IOLD	Variable used in determining whether or not a new physiological day has occurred.
ISTSQR	Trigger for subroutine PLTMAP. Time is physiological time to first square.
JB	Number used to select how often plant will be printed out. Used when LAST equals zero.
JJ	Time from emergence.
JJK	Trigger used in selecting output format of the program. First day to be listed.
JNEXT	Trigger for output in answering question from computer terminal "Do you want plant printed out on day JJ?" Answer "Zero" for "Yes;" "1" for 'No."
JPLDAY	Day of emergence.
JSEASN	SEASON+2 Trigger to end simulation.
KCARDS	Number of days of weather to be read into KLYMAT by the computer.
KLYMAT(J,I)	Environmental input to program. J is maximum number of days, equal to 300. I refers to different environmental variables. 1 is solar radiation in langleys per day. 2 is maximum daily temperature in degrees Fahrenheit. 3 is minimum daily temperature in degrees Fahrenheit. 4 is rainfall in inches per day. 5 is pan evaporation in inches per day. 6 is Julian day number. 7 is a CO_2 trigger.
LAI	Leaf-area index (DM^2/DM^2).
LAST	Trigger used in modifying matrices for simulating insect damage of plant. Zero means no changes, 1 means changes in matrix.
LATUDE	Latitude of crop being simulated.
LEAFW	Previous day's leaf weight. Used in calculating senescence.
LEFRNU	Exponent used to adjust growth rate of leaves. Equal to 1.
LEFSTF	Percentage of leaf weight that can be used to store excess carbohydrate.
LEFWT	Active tissue weight of leaves. Range 0 through 70 days.
LOSTD	Standard controlling boll setting.

MATURE	SEASON + 1 Trigger to end simulation.
MINFAC	Constant used in calculating the declination. Equal to 0.0002909.
MINUTS	Variable used in calculating the declination.
NBRV	Number of nodes on longest fruiting branch of vegetative branch.
NEWDAY	Trigger used in telling when a new physiological day has occurred. 1 is new. Zero is same.
NGREEN	Not used.
NOBRI	Number nodes on longest fruiting branch of main stem.
NONOD	Nth node of main stem.
NSUM	Total fruiting sites.
NSUMMB	Total number of mature bolls.
NSUMBO	Total number of green bolls.
NSUMNO	Number of main-stem nodes.
NSUMSQ	Total number of squares.
NUMBER	Number of fruit to be removed (changed) on main stem.
NUMBV	Number of fruit to be removed (changed) on vegetative branch.
NUMGRN	Number of green bolls.
NUMOPN	Number of open bolls.
NVEG	Nth node of vegetative branch main stem.
NYTTYM	Factor used in finding average night temperature from minimum daily temperature.
NYTFAC	Physiological time of night. Based on temperature.
PAVAIL	Available photosynthate for growth.
PBOLL(J)	Boll; weight increments. J is days from flower where flower is day 1.
PCOT(J,I)	Daily weight increment of plant parts. J is day from emergence. I classifies plant part. 1 is roots, 3 is stems, 5 is leaves, and 7 is flowers. 2, 4, 6, 8, and 9 are not used.
PLANT	Total plant weight.
PLANTW	Total plant weight less any mature boll weight.
PLTDAY	Day of emergence.
POLYNA	Polination factor. Zero is conditions favorable for polination. 1 is conditions unfavorable for polination.
POPFAC	DMACRE/POPPLT.
POPPLT	Number of plants per acre.
PQBOLX	Growth requirement of bolls on daily basis.
PREQ	Photosynthate required for 1 day's growth.
PRES	Permanent reserve of photosynthate.
PRESX	Permanent reserve of photosynthate.
PRT(L,M) PRI(L,M)	Matrices used in printing alphanumeric representation of main plant.
PRTV(LV,MV) PRIV(LV,MV)	Matrices used in listing alphanumeric representation of vegetative branch. X is square, * is green boll, # is mature boll, O is abscised fruit site or main-stem node, I is fruiting branch internode, and = is main-stem internode.
RADFAC	Radian factor used to convert degrees to radians.
RESADD	Fraction of stalk storage available per day.
RESUFC	Maximum stalk reserves as fractions of stalk weight.
RFALL	Daily rainfall.
ROOTWT	Active tissue weight of roots. Active range, 0 through 24 days.
ROWSP	Row spacing in centimeters.
RSUBO	Maintenance respiration as fraction of plant weight.
RTS	Root weight.
RTSRUT	Exponent used to adjust root growth.
SEASON	Length of season from day of emergence in days.
SINLAT	SIN(LATUDE).
SOILW(I)	I is 10 layers of soil. Each layer is one-tenth of rooting depth. SOILW (I) is water content of the Ith layer.
SQLOST	Number of squares lost on a given day due to carbohydrate shortage.
STMRUT	Exponent used to adjust stem growth.
STMWT	Active tissue weight of stems. Active range, 0 through 24 days.
STRLMT	Stress that stops leaf growth.
SUMLEF	Leaf weight.
SUMRTS	Root weight.
SUMSTM	Stem weight.
TIME	Real time increment.
TOPRES	Maximum leaf reserve storage of photosynthate as fraction of leaf weight.
TRES	Temporary reserve of excess photosynthate.
TRNSLF	Factor to limit translocation from leaves during day.
TTL(I)	Title; for example, "Mississippi Weather for 1961."
WTBOLL(L,M)	Total individual boll weights. L is main-stem node number. M is fruiting branch node number. The first node of a fruiting branch is on the main stem.
WTBOLV (LV,MV)	Individual boll weights on vegetative branch.
XSTRES	Carbohydrate stress. 0 through 4 integer values.
XSTRESS(7,5)	Table of values assigning a numerical value to the stress resulting from the combination of soil water content and evaporative demand as measured by pan evaporation.

Any other variables not defined above are concerned with printout of the program.

Subroutine SUNTYM

COSDCL	COS(DCLVAL).
DAYLNG	Length of daylight in hours.
DCLVAL	Declination for day JDAY.
JDAY	Julian day.

SINDCL	SIN(DCLVAL).
SUNRIZ	Time from solar noon to sunrise.

Subroutine WATERZ

EXIT	Trigger indicating that H2OEXC is less than zero.
H2ODEF	Soil water deficiency.
H2OEXC	Excess soil water after deficit has been taken care of.
K	Number of layers of soil WRT rooting depth.
KMOIST	Variable used to calculate second subscript of XSTRES(EVAP, NSW).
NSW	Subscript of array XSTRESS (EVAP,NSW).
PANVAP	Pan evaporation in inches per day.
WATER	Rainfall (irrigation).

Subroutine PHZDAZ

DAYT	Daytime physiological time based on temperature and length of day.
DAYTYM	Fractional physiological time of day.
MAXMIN	Difference between maximum daily temperature and minimum daily temperature.
NYTT	Nighttime physiological time based on temperature and length of night.
NYTTYM	Fractional physiological time of night.
TAVG	Average 24-hour temperature.

Subroutine PNET

BMAIN	Photosynthate required to maintain present plant material.
LYTCPT	Fraction of incident solar radiation intercepted as function of LAI.
LYTRES	Light respiration.
PN	Net photosynthate.
PPLANT	Photosynthate produced per plant.
PSTAND	Photosynthate produced by stand of plants as function of WATTSM.
PTS	Photosynthate after light respiration and maintenance have been subtracted.
PTSRED	Photosynthate reduction factor.
RSUBL	Coefficient for light respiration.
WATTSM	Solar radiation in watts per square meter.

Subroutine QPREQZ

F	Not used.
LEFADD	Factor used to adjust LAI for crops with different populations.
NAGE	Age of fruit from initiation of square.
PQBOLD	Boll photosynthate requirement for full growth during day.
PQBOLN	Boll photosynthate requirement for full growth during night.
PQBOLX	Total boll requirement for 24 hours.
PQLEFD	Photosynthate required for full leaf growth during day.
PQLEFN	Photosynthate required for full leaf growth during night.
PQRESN	Requirement for rebuilding depleted reserves.
PQRTSD	Photosynthate required for full root growth during day.
PQRTSN	Photosynthate required for full root growth during night.
PQSTMD	Photosynthate required for full stem growth during day.
PQSTMN	Photosynthate required for full stem growth during night.
QLEF	Not used. Equal to QUAN.
QRTS	Not used. Equal to QUAN.
QSTM	Not used. Equal to QUAN.
QUAN	Constant to obtain proper proportioning of photosynthate.

Subroutine PQDAYZ

F	Ratio of available photosynthate to that required.
ROTW	Variable used to calculate root senescence.
STMW	Variable used to calculate stem senescence.
TRESXX	Maximum photosynthate that can be translocated during day.

Subroutine PQNYTZ

ABC	Variable used to see if boll setting requirements are met.
PREQZ	Photosynthate required for growth if roots are not grown.
STQN	Same as PREQZ.
TSLIMT	Maximum photosynthate that can be stored in leaves.

Subroutine NITR

AD	Actual root volume depth.
AL	Actual root volume length.
APPL	Sidedressing.
AW	Actual root volume width.
BCON	Burr concentration of nitrogen by weight.
BOL1	Nitrogen requirement for today's boll growth.
BURMIN	Maximum nitrogen requirement for today's burr growth.
BURR	Maximum burr usage capacity for nitrogen.
BURR1	Nitrogen requirement for today's burr growth.
CD	Depth of maximum root volume per plant.
CL	Length of maximum root volume per plant.
COTTON	Total mature and green cotton weight.
CW	Width of maximum root volume per plant.
DEFCIT	Difference between boll growth requirement for nitrogen and nitrogen taken up from soil.

DREQN	Maximum capacity of plant for storage of nitrogen.
EFN	Efficiency of application of preemergence application and sidedressing (if any).
EXC	Amount of nitrogen taken up above needs of plant for growth.
GRGR	Amount of fruit growth on plant.
LCONC	Leaf concentration of nitrogen by weight.
LEFR	Maximum carbohydrate storage capacity of leaves.
LEFR1	Nitrogen requirement for today's leaf growth.
LEFRS	Reserve nitrogen stored in leaves.
NMAX(I)	Maximum nitrogen concentration possible in plant parts. I is used as follows: 1, seed; 3, burrs; 4, stems; 5, roots.
NMIN(I)	Minimum nitrogen concentrations possible in plant parts as defined for NMAX(I).
NPART	Actual nitrogen in plant parts. I is defined as NMAX(I).
NSTRES	Nitrogen stress factor for reduction of growth and abscission of fruit.
PERN	Organic nitrogen pool in soil.
POM	Percentage of organic matter.
R	Rainfall in inches.
RCON	Nitrogen concentration in roots by weight.
REQ1	Nitrogen requirement for today's plant growth.
RESN	Reserve nitrogen available in plants for growth of fruit.
ROTR	Maximum capacity of roots for nitrogen.
ROTR1	Nitrogen requirement for today's root growth.
ROTRS	Reserve nitrogen in roots available for fruit growth.
RTOT	Cumulative sum of nitrogen demanded by the plant.
SCON	Seed concentration of nitrogen by weight.
SEEDR	Maximum seed usage capacity for nitrogen.
SEEDR1	Nitrogen requirement for today's fruit growth.
STCON	Nitrogen concentration in stems by weight.
STMR	Maximum capacity of stems for nitrogen.
STMR1	Nitrogen requirement for today's stem growth.
STMRS	Reserve nitrogen in stems available for fruit growth.
SUPR	Factor used for partitioning nitrogen among plant parts.
SUPR1	Factor used in partitioning nitrogen among plant parts.
TEMN	Soil pool of available nitrogen.
TOTAL	Plant requirement for growth plus excess nitrogen (if any) taken up.
USE	Parameter indicating rate of depletion of reserves.
VPLT	Actual root volume.
VTOT	Maximum root volume per plant.
WCOTX	Yesterday's mature cotton weight.
WGRCOT	Yesterday's green cotton weight.
WLEF	Yesterday's leaf weight.
WROT	Yesterday's root weight.
WSTM	Yesterday's stem weight.
XN	Maximum amount of nitrogen plant can take up per day.
XNUP	Nitrogen uptake of plant.
XNUP1	Amount of nitrogen taken up by plant.

Subroutine PLTMAP

AVTEMP	Accumulated average temperature for first 31 physiological days.
DSQ	Day of squaring on main stem.
DSV	Day of squaring on vegetative branch.
ICNOD	Trigger for adding new node to main-stem fruiting branch.
INOD	Main-stem node on plant at which the first square will appear.
ISQ	Trigger for telling when first square is on plant.
IVNOD	Trigger for adding new node to vegetative fruiting branch.
JK JKV	Matrices for determining when fruit will be abscised after triggering the abscission process.
LEAFWT(JJ)	Variable used to senesce leaf material.
NOBR	Maximum number of nodes on a main-stem fruiting branch.
NTL	Trigger for adding squares to a fruiting branch, from the main stem.
NTLV	Trigger for adding squares to a fruiting branch for a vegetative branch.
NV	Number of nodes on vegetative main stem.
PQBOLD	Photosynthate available for today's boll growth.
PQBOLN	Photosynthate available for tonight's boll growth.
PQBOLX	Total required photosynthate for maximum boll growth for 24 hours.
ROOTW(JJ)	Variable used to senesce root material.
STEM(JJ)	Variable used to senesce stem material.
TAVL	Running average temperature of nodes on main stem.
TBRV	Time till next node on vegetative fruiting branch.
T(L)	Time till next node on main-stem fruiting branch.
TMAIN	Time till next node on main stem.
TMPV	Running average temperature of nodes on vegetative branch.

TV	Time till next node on vegetative main stem.
WLOST	Total root and stem material senesced on this day.
XM	Variable used in calculating maximum number of nodes on a mainstem fruiting branch, based on plant population.

PROGRAM SETUP AND EXECUTION

SIMCOT II is written in FORTRAN IV level G and has been run on the IBM 370-155 system at Clemson University and on the UNIVAC 1106 at Mississippi State University. The IBM 370-155 uses 91 K bytes of storage, and run time with a typical 10-day mapping output is 55 seconds. Comparable figures for the Univac 1106 are 23 K words and 34 seconds. We normally employ disk files for program and data sets, and we usually operate from terminal. In converting to Univac or IBM equipment the arc cosine term in SUNTYM must be used appropriately.

SIMCOT II can be used for plant population studies with up to 80,000 plants per acre. An appropriate "LEFADD" factor from table 4-1 and the per-acre plant population must be supplied as indicated on line 288 of the sample data.

Carbon dioxide fertilization experiments can be made by inserting a 1 in the appropriate column of the climate data. This provides 500 p/m CO_2 in the upper part of the plant canopy during 6 midday hours (roughly equivalent to 200 lb CO_2/acre/hour).

Photosynthetic efficiency can be varied by appropriate change in PNEFF in line 288 of sample data.

Nitrogen fertility studies can be made with different planting applications (INITIALN= pounds N per acre on line 290 of the sample data set) or by sidedressing with appropriate levels of APPL in pounds N per acre on line 36 of NITR.

Row-spacing studies can be made by changing ROWSP on line 288 of the sample data.

Soil-moisture studies require appropriate values for inches of water holding capacity in the top 12 inches (SOIL CAP on line 288 of the sample data) and may require changes in lines 18–24 of WATERZ on lines 281 to 283 of the sample data to reflect the effect of various climates on plant water status. We have not yet attempted to validate over a range of moisture stress conditions for different soils.

Emergence date studies can be done by changing EMERGE on line 288 of the sample data.

PROGRAM LISTING

```
MCKIN+TF.K
      BLOCK DATA
      COMMON /COM/FR,DAY,I,JJ,PCOT,ISTSQR
      INTEGER FR(45,8 )
      DATA FR/360*0/
      REAL PCOT(200,9)
      DATA DAY/0./,ISTSQR/0/
      END
```

```
MCKIN*TF.A
      DIMENSION PCOT(200,9),PBOLL(60),KLYMAT(300,7),XSTRES(
     &7,5),WTBOLL(45,8 ),CLIMAT(300,7)
      DIMENSION SOILW(10),ESUBT(5),          WTBOLV(30,5)
      INTEGER TTL(20)
      DIMENSION DECL(365),DECLIN(365)
      DIMENSION ATL(4)
      COMMON /COM/FR,DAY,I,JJ,PCOT,ISTSQR
      COMMON STMWT,ROOTWT
      INTEGER FR(45,8 )
      INTEGER SQLOST,BOLLST,BLOOM,FRVL
      INTEGER CHARX/'X'/,CHARS/'*'/,CHARN/'#'/,CHARI/'I'/,CHARO/'0'/
      INTEGER FRV(30,5)/150*0/,FAGV(30,5)/150*0/,PRTV(30,5)/150*' '/,
     1PRIV(30,5)/150*' '/
      INTEGER XTRES/0/,CO2/0/
      INTEGER FAGE(45,8 )/360*0/,POLYNA/0/
      INTEGER PRT(45,8 )/360*' '/,PRI(45,8 )/360*' '/
      REAL NMAX(5),NMIN(5),NPART(5)/5*0./,LCONC/0./
      REAL LEAFW
      REAL LEFWT,LO STD,LAI,                        NYTFAC,            NYTT
     1YM,       LATUDE,MINUTS,MINFAC,KLYMAT,                     LEFSTF
      REAL WLOST(3)/3*0./,AGE/0./
      DATA WTBOLL/360*0./,HISTD/.1/,LOSTD/.2/,STRLMT/.71/,TRNSLF/.2/
      DATA WTBOLV/150*0./,DAYFAC/.55/,NYTFAC/.45/,EVAPFC/.75/,RSUBO/
     1.0032/,ALAIFC/1.2/,TOPRSF/0./,RESUFC/.6/,RESADD/.8/,GSUBR/.375/,
     2LEFSTF/.3/,NMIN(1)/.02/,NMIN(2)/.04/,NMIN(3)/.006/,NMIN(4)/.009/,
     3NMAX(1)/.042/,NMAX(2)/.04/,NMAX(3)/.02/,NMAX(4)/.02/
      DATA ATL/'DAY',' VS',' BOL',' INC'/
      DATA SUMLEF/0./,SUMSTM/0./,SUMRTS/0./,GRCOTX/0./,NUMGPN/0/,NUMOPN/
     10/,DIFSUM/0./,DMACRE/404700./,COTXX/0./,TOPRES/0./,PAVAIL/0./,TRES
     2/0./,          POLYNA/0/,SQLOST/0/,BOLLST/0/,LAI/.01/,PLANTW/1./,
     3 PRESX/.01/,PQBOLX/1./,PRES/.01/,RTS/1./,PREQ/0./,NEWDAY/
     40/,IOLD/0/,H2ORUN/0./
      READ(5,1000)((PCOT(K,J),J=1,9),K=1,41)
 1000 FORMAT(9F5.0)
      READ(5,1005)(PBOLL(J),J=1,60)
 1005 FORMAT(16F5.0)
      READ(5,1003)TTL
 1003 FORMAT(20A4)
      READ(5,1001)KCARDS
 1001 FORMAT(I10)
      READ(5,1010)((KLYMAT(K,J),J=1,7),K=1,KCARDS)
 1010 FORMAT(7F10.0)
      READ(5,1025)(DECLIN(J),J=1,365)
 1025 FORMAT(16F5.2)
      DO 2222 J=2,365
 2222 IF(ABS(DECLIN(J)).LT.0.5)DECLIN(J)=DECLIN(J-1)
      READ(5,1015)((XSTRES(J,K),K=1,5),J=1,7)
 1015 FORMAT(15F5.0)
      DO 786 J=42,200
      PCOT(J,1)=.08
      PCOT(J,2)=.0
      PCOT(J,3)=.80
      PCOT(J,4)=0.
      PCOT(J,5)=.60
      PCOT(J,6)=.0
      PCOT(J,7)=PCOT(41,7)
      PCOT(J,8)=0.
  786 PCOT(J,9)=15.00
```

PROGRAM LISTING—Continued

```
C DESCRIPTIONS OF THE ENVIRONMENT: LATITUDE, LENGTH OF SEASON,WATER
C CAPACITY OF THE SOIL IN INCHES PER TENTH OF THE ROOTING DEPTH
6      READ(5,1020)LATUDE,SEASON,H2OCAP,EMERGE,ROWSP,ADD,EFF,POPPLT
C MANAGEMENT O& THE CR-P: PLANTING DAY -& THE YEAR, PLANTS PER ACRE
C      ROW SPACING, CENTIMETERS
2      READ(5,1020)POM,EFN,TEMN,RESIDN
 1020  FORMAT(8F10.0)
       TEMN=(TEMN*EFN/POPPLT)*453.6+RESIDN*453.6/POPPLT
       READ(5,7055)JJK,LAST,JB
7055   FORMAT(3I5)
       FLOWER=30000/POPPLT
       BALEFC=.0000014*POPPLT
       WS=0
       WR=0
       WL=0
       MINFAC=.0002909
       JSEASN=SEASON+2.
       MATURE=SEASON+1.
       NGREEN=SEASON-2.
       RADFAC=.0174533
       LATUDE=LATUDE*RADFAC
       JPLDAY=EMERGE
       SINLAT=SIN(LATUDE)
       COSLAT=COS(LATUDE)
       DO 8 J=1,365
       K=DECLIN(J)
       DEGRES=K
       MINUTS=DECLIN(J)-DEGRES
     8 DECL(J)=DEGRES*RADFAC+MINUTS*MINFAC*100.
       K=1
       DO 21 J=1,KCARDS
       CLIMXX=KLYMAT(J,6)-EMERGE
       IF(CLIMXX.LE.0.)GO TO 21
       CLIMAT(K,7)=KLYMAT(J,7)
       CLIMAT(K,6)=KLYMAT(J,6)
       CLIMAT(K,5)=KLYMAT(J,5)
       CLIMAT(K,4)=KLYMAT(J,4)
       CLIMAT(K,3)=(KLYMAT(J,3)-32.)*5./9.
       CLIMAT(K,2)=(KLYMAT(J,2)-32.)*5./9.
       CLIMAT(K,1)=KLYMAT(J,1)
       K=K+1
    21 CONTINUE
       ESUBT(1)=EVAPFC*.5
       ESUBT(2)=EVAPFC*.7
       ESUBT(3)=EVAPFC*.8
       ESUBT(4)=EVAPFC*.9
       ESUBT(5)=EVAPFC
       POPFAC=DMACRE/POPPLT
       ROOTWT=PCOT(1,1)
       STMWT =PCOT(1,3)
       LEFWT=PCOT(1,5)
       I=1
       WRITE(6,1004)TTL
1004   FORMAT(' ',20A4)
       DO 145 J=1,10
   145 SOILW(J)=H2OCAP
       TIME=1.
       DO 998 JJ=1,JSEASN
       JNEXT=0
       AGE=AGE+TIME
       IF(AGE.GT.SEASON)GO TO 998
       H2OREM=0.
       RFALL=CLIMAT(JJ,4)
       CALL SUNTYM(JPLDAY,DECL,DAYLNG,SINLAT,COSLAT)
       CALL WATERZ(CLIMAT,H2OCAP,H2ORUN,STRESS,XSTRES,SOILW,ESUBT,H2ODEF)
       CALL PHZWAZ(CLIMAT,DAYFAC,NYTFAC,DAYLNG,IOLD,TDAY,TNYT,DAYTYM,
      1NYTTYM,TFACD,TFACN,NEWDAY,TAVG)
       CALL PNET(LAI,CLIMAT,POPFAC,PLANTW,DAYTYM,NYTTYM,RSUBO,PN,STRESS,
      1TDAY,LYTRES,GSUBR,CO2,EFF,ROWSP,NMIN,LCONC)
       CALL QPREQZ(PQLEFD,PQLEFN,PQSTMD,PQSTMN,PQRTSD,PQRTSN,PQBOLD,PQBOL
      1N,PQRESN,PQFLR,PBOLL,NYTTYM,DAYTYM,PQBOLX,TFACD,TFACN,TOPRES,PRES,
      2RESADD,NEWDAY,LEFWT,SUMLEF,SUMSTM,SUMRTS,
      3INOD,NONOD,NOBR,FAGE,NVEG,NBRV,FRV,FAGV,NFL,ADD,NSTRES)
       CALL PQDAYZ(STRESS,STRLMT,PQLEFD,PQSTMD,PQRTSD,PQBOLD,TRES,PRES,
      1PN,RESUFC,LEFWT,XTRES,TRNSLF,LEAFW,STMW,ROTW)
       CALL PQNYTZ(PQLEFN,PQSTMN,PQRTSN,PQBOLN,PQRESN,PQFLR,TRES,
```

PROGRAM LISTING—Continued

```
     1LEFWT,PRES,TOPRES,HISTD,LOSTD,XTRES,LEFSTF,POLYNA,RESUFC,
     2PN,TOPRSF,STRESS,RFALL)
      CALL PLTMAP(PBOLL,WTBOLL,TAVG,NEWDAY,PQBOLN,PQBOLD,PQBOLX,XTRES,
     1NOBR1,NONOD,BOLLST,SQLOST,COTXX,GRCOTX,ROWSP,PQFLR,POLYNA,FAGE,
     2INOD,NOBR,POPPLT,NUMGRN,NUMOPN,NVEG,NBRV,FRV,FAGV,WTBOLV,NV,BLOOM,
     3LEAFW,LEFWT,NFL,CLIMAT,STMW,ROTW,GBLOS,WLOST,NSTRES)
      CALL NITR(RDEP,POM,EFN,TEMN,NMAX,NMIN,     ROWSP,PERN,POPPLT,
     1NPART,NSTRES,RESN,DREQN,DEFCIT,USE,LCONC,H2ODEF,H2OCAP,GBLOS,
     2LEFWT,COTXX,GRCOTX,RFALL,JJK,FRVL,WS,WR)
      WS=WS+WLOST(1)
      WR=WR+WLOST(2)
      PLANT=LEFWT+STMWT+ROOTWT+GRCOTX+COTXX+PRES+WLOST(1)+WLOST(2)+WLOS
     *T(3)
      PLANTW=PLANT-COTXX
      DO 180 J=1,10
  180 H2OREM=H2OREM+SOILW(J)
      H2OREX=H2OREM
      BALECT=COTXX*BALEFC
      LAI=LEFWT*ALAIFC/POPFAC
      IF(I.LT.ISTSQR+1)GO TO 750
      NSUM=0
      NSUMMB=0
      NSUMNO=0
      NCOUNT=0
      NSUMSQ=0
      NSUMBO=0
      DO 728 L=1,NONOD
      DO 728 M=1,NOBR1
      IF(FR(L,M).EQ.0)GO TO 728
      IF(FR(L,M).EQ.1)PRT(L,M)=CHARX
      IF(FR(L,M).EQ.2)PRT(L,M)=CHARS
      IF(FR(L,M).EQ.3)PRT(L,M)=CHARN
      IF(FR(L,M).EQ.4)PRT(L,M)=CHARO
      IF(FR(L,M).EQ.5)PRT(L,M)=CHARX
      IF(FR(L,M).EQ.6)PRT(L,M)=CHARS
      IF(FR(L,M).EQ.1.OR.FR(L,M).EQ.5)NSUMSQ=NSUMSQ+1
      IF(FR(L,M).EQ.1.AND.FAGE(L,M).GE.12)NCOUNT=NCOUNT+1
      IF(FR(L,M).EQ.5.AND.FAGE(L,M).GE.12)NCOUNT=NCOUNT+1
      IF(FR(L,M).EQ.2.OR.FR(L,M).EQ.6)NSUMBO=NSUMBO+1
      IF(FR(L,M).EQ.3)NSUMMB=NSUMMB+1
      IF(FR(L,M).EQ.4)NSUMNO=NSUMNO+1
      PRI(L,M)=CHARI
  728 CONTINUE
      DO 828 LV=1,NVEG
      DO 828 MV=1,NBRV
      IF(FRV(LV,MV).EQ.0) GO TO 828
      IF(FRV(LV,MV).EQ.1)PRTV(LV,MV)=CHARX
      IF(FRV(LV,MV).EQ.2)PRTV(LV,MV)=CHARS
      IF(FRV(LV,MV).EQ.3)PRTV(LV,MV)=CHARN
      IF(FRV(LV,MV).EQ.4)PRTV(LV,MV)=CHARO
      IF(FRV(LV,MV).EQ.5)PRTV(LV,MV)=CHARX
      IF(FRV(LV,MV).EQ.6)PRTV(LV,MV)=CHARS
      IF(FRV(LV,MV).EQ.1.OR.FRV(LV,MV).EQ.5)NSUMSQ=NSUMSQ+1
      IF(FRV(LV,MV).EQ.1.AND.FAGV(LV,MV).GE.12)NCOUNT=NCOUNT+1
      IF(FRV(LV,MV).EQ.5.AND.FAGV(LV,MV).GE.12)NCOUNT=NCOUNT+1
      IF(FRV(LV,MV).EQ.2.OR.FRV(LV,MV).EQ.6)NSUMBO=NSUMBO+1
      IF(FRV(LV,MV).EQ.3)NSUMMB=NSUMMB+1
      IF(FRV(LV,MV).EQ.4)NSUMNO=NSUMNO+1
      PRIV(LV,MV)=CHARI
  828 CONTINUE
      IF(LAST.EQ.0)GO TO 5005
      IF(JJ.NE.JJK)GOTO 7000
      WRITE(6,211)JJ
211   FORMAT(' ','HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY
     1',I4,'?')
      READ(5,3065) NUMBER
      WRITE(6,3065)NUMBER
 3065 FORMAT(I5)
      IF(NUMBER.LE.0)GO TO 30
      DO 31 I=1,NUMBER
      WRITE(6,212)JJ
212   FORMAT(' ','WHICH FRUIT ON MAIN  BRANCH WILL BE ABSCISED ON DAY ',
     1I4,'?')
      READ(5,1)L,M,FR(L,M)
      WRITE(6,1)L,M,FR(L,M)
31    CONTINUE
```

PROGRAM LISTING—Continued

```
30     CONTINUE
       WRITE(6,214)JJ
214    FORMAT(' ','HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY
      1',I4,' ?')
       READ(5,3065) NUMBV
       WRITE(6,3065)NUMBV
       IF(NUMBV.LE.0)GO TO 33
       DO 32 I=1,NUMBV
       WRITE(6,215)JJ
215    FORMAT(' ','WHICH FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY
      1I4,'?')
       READ(5,1)LV,MV,FRV(LV,MV)
       WRITE(6,1)LV,MV,FRV(LV,MV)
 1     FORMAT(5I5)
32     CONTINUE
33     CONTINUE
       WRITE(6,216)JJ
216    FORMAT(' ','DO YOU WANT PLANT  PRINTED OUT ON DAY ',I4,'?')
       READ(5,1)JNEXT
       WRITE(6,1)JNEXT
       JJK=JJK+JNEXT
       WRITE(6,213)JJ
213    FORMAT(' ','IS THERE ANY MORE DATA AFTER DAY ',I4,'?')
       READ(5,3070)LAST
       WRITE(6,3070)LAST
3070   FORMAT(I5)
7000   CONTINUE
5005   CONTINUE
       NSUN=NSUMSQ+NSUMBO+NSUMNO+NSUMMB-NONOD-NV
8010   CONTINUE
       IF(NOBR1.LT.2)GO TO 746
       NOBR2=NOBR1-1
       DO 738 M=1,NOBR2
       M1=NOBR1-M+1
       IF(JJ.NE.JJK)GO TO 8001
       WRITE(6,739)(PRT(L,M1),L=1,NONOD,2)
   739 FORMAT(' ',2X,32(A1,3X))
8001   CONTINUE
       IF(JJ.NE.JJK)GO TO 8007
       WRITE(6,739)(PRI(L,M1),L=1,NONOD,2)
8007   CONTINUE
738    CONTINUE
746    CONTINUE
       IF(JJ.NE.JJK)GO TO 8008
       WRITE(6,740)(PRT(L,1),L=1,NONOD)
   740 FORMAT(' ','==',64(A1,'='))
8008   CONTINUE
       IF(NOBR1.LT.2)GO TO 750
       IF(JJ.NE.JJK)GO TO 8002
       DO 741 M=2,NOBR1
       WRITE(6,760)(PRI(L,M),L=2,NONOD,2)
   741 WRITE(6,760)(PRT(L,M),L=2,NONOD,2)
   760 FORMAT(' ',4X,32(A1,3X))
   750 CONTINUE
       IF(JJ.NE.JJK)GO TO 8002
       WRITE(6,751)JJ,XTRES,STRESS,CLIMAT(JJ,1),PLANT
751    FORMAT(' ','DAY ',I3,'  CH2O STRESS ',I1,'  H2O STRESS ',F4.1,'
      1SOLAR RAD ',F5.0,'  PLANT WT ',F6.2)
       WRITE(6,752) SQLOST,BOLLST,LAI,I,BLOOM
752    FORMAT(' ','SQUARES LOST ',I2,'  BOLLS LOST ',I2,'  LAI ',F4.2,
      1'  PHYSIOL. DAYS ',I3,'  BLOOMS LOST ',I2)
       WRITE(6,753)LEFWT,NONOD,NSUMSQ,NSUMBO,NSUM
753    FORMAT(' ','LEAF WT ',F5.2,'  MAINSTEM NODES ',I2,' # SQUARES '
      2,I3,' # GREEN BOLLS ',I2,' # SITES ',I3,//)
  8002 CONTINUE
       IF(I.LT.ISTSQR+1) GO TO 870
       NBRV2=NBRV-1
       IF(NBRV2.LT.1) GO TO 846
       DO 838 MV=1,NBRV2
       MV1=NBRV-MV+1
       IF(JJ.NE.JJK)GO TO 8009
       WRITE(6,739) (PRTV(LV,MV1),LV=1,NVEG,2)
       WRITE(6,739) (PRIV(LV,MV1),LV=1,NVEG,2)
8009   CONTINUE
838    CONTINUE
846    CONTINUE
       IF(JJ.NE.JJK)GO TO 8003
```

PROGRAM LISTING—Continued

```
            WRITE(6,740) (PRTV(LV,1),LV=1,NV)
      8003  CONTINUE
            IF(NBRV2.LT.1) GO TO 850
            IF(JJ.NE.JJK)GO TO 8005
            DO 841 MV=2,NBRV
            WRITE(6,760) (PRIV(LV,MV),LV=2,NVEG,2)
        841 WRITE(6,760) (PRTV(LV,MV),LV=2,NVEG,2)
      8005  CONTINUE
        850 CONTINUE
            INODV=INOD-1
            IF(JJ.NE.JJK)GO TO 870
            IF(INODV.LT.0)GO TO 870
            WRITE(6,901) INODV
        901 FORMAT(' ','VEGETATIVE BRANCH GROWING FROM NODE',I3,2X,'OF THE MAI
           1N STEM',//)
      8006  CONTINUE
      870   CONTINUE
            JJK=JJK-JNEXT
            IF(JJ.NE.JJK)GO TO 8011
            IF(LAST.EQ.0)GO TO 5515
            WRITE(6,220)JJ
      220   FORMAT(' ','THIS IS DAY ',I4,5X,'WHAT IS THE NEXT OUTPUT DAY?')
            READ(5,3065)JJK
      5515  CONTINUE
            IF(LAST.EQ.1)GO TO 5505
            JJK=JJK+JB
      5505  CONTINUE
      8011  CONTINUE
        99B CONTINUE
            LATUDE=LATUDE/RADFAC
            WRITE(6,1050)BALECT,EMERGE,JSEASN,LATUDE
      1050  FORMAT(' ',' YIELD/ACRE ',F5.3,'  EMERGENCE DATE ',F4.0,'  GROWING
           1DAYS ',I3,'  LATITUDE ',F5.1)
            WRITE(6,1051)NUMGRN,NUMOPN,H2OCAP
      1051  FORMAT(' ','# GREEN BOLLS ',I2,' # OF OPEN BOLLS ',I2,'  SOIL H2O
           2 CAPACITY ',F4.2)
            WRITE(6,1052)H2ORUN,ROWSP,POPPLT
      1052  FORMAT(13H H2O RUN OFF ,F4.2,14H  ROW SPACING ,F6.1,19H  # OF PLAN
           1TS/ACRE ,F7.0)
            STOP
            END
```

```
CPRT  TF.B
```

```
MCKIN*TF.8
            SUBROUTINE SUNTYM(    JPLDAY,DECL,DAYLNG,SINLAT,COSLAT)
      C     THIS SUBROUTINE COMPUTES THE LENGTH OF DAY FOR ANY DAY OF THE YEAR
      C     JPLDAY IS THE DAY OF PLANTING, DAYLNG IS THE DURATION OF SUNLIGHT
      C     IN HOURS.
      C     DECL REFERS TO A TABLE OF DECLINATIONS GIVING DECLINATIONS FOR EAC
            DIMENSION DECL(365),PCOT(200,9)
            COMMON /COM/FR,DAY,I,JJ,PCOT,ISTSQR
            INTEGER FR(45,8 )
            RADFAC=.0174533
            JDAY=JJ+JPLDAY
            DCLVAL=DECL(JDAY)
            SINDCL= SIN(DCLVAL)
            COSDCL=COS(DCLVAL)
            SUNRIZ=(-SINLAT*SINDCL)/(COSLAT*COSDCL)
            SUNRIZ= ACOS(SUNRIZ)/RADFAC
            DAYLNG=(SUNRIZ/15.)*2.
            RETURN
            END
```

```
MCKIN*TF.C
            SUBROUTINE WATERZ(    CLIMAT,H2OCAP,H2ORUN,STRESS,XSTRES,SOILW,
           1ESUBT,H2ODEF)
      C     SUBROUTINE WATERZ ADJUSTS SOIL MOISTURE FOR EVAPORATION AND
      C     RAINFALL AND EVALUATES PLANT STRESS IN TERMS OF WATER REMAINING IN
      C     THE SOIL AND THE PAN EVAPORATION FOR THE DAY - ARBITRARILY.
      C     CLIMAT IS RAINFALL AND PAN EVAPORATION FOR THE DAY INDICATED
```

PROGRAM LISTING—Continued

```
C     H2OCAP IS THE USEFUL WATER IN INCHES PER TENTH OF THE ROOTING
C     DEPTH
C     H2ORUN IS THE COMPUTED RUNOFF OR SOAKTHROUGH
C     XSTRESS REFERS TO A TABLE OF VALUES ASSIGNING'A NUMERICAL VALUE TO
C     THE STRESS RESULTING FROM THE COMBINATION OF SOIL WATER CONTENT AN
C     EVAPORATIVE DEMAND AS MEASURED BY PAN EVAPORATION
C     SOILW IS THE USEFUL WATER PER TENTH OF THE ROOTING DEPTH
      DIMENSION CLIMAT(300,7),XSTRES(7,5),SOILW(10),ESUBT(5),PCOT(200,9)
      INTEGER EVAP,FR(45,8 )
      COMMON /COM/FR,DAY,I,JJ,PCOT,ISTSQR
      COMMON  STMWT,ROOTWT
      IF(CLIMAT(JJ,5).LT.2.0)EVAP=7
      IF(CLIMAT(JJ,5).LT..47)EVAP=6
      IF(CLIMAT(JJ,5).LT..39)EVAP=5
      IF(CLIMAT(JJ,5).LT..31)EVAP=4
      IF(CLIMAT(JJ,5).LT..23)EVAP=3
      IF(CLIMAT(JJ,5).LT..15)EVAP=2
      IF(CLIMAT(JJ,5).LT..07)EVAP=1
      H2ODEF=0.
      IF(CLIMAT(JJ,4).LT..02)GO TO 175
      DO 153 J=1,10
  153 H2ODEF=H2ODEF+H2OCAP-SOILW(J)
      H2OEXC=CLIMAT(JJ,4)-H2ODEF
      IF(H2OEXC.GT.0.)GO TO 154
      EXIT=0.
      WATER=CLIMAT(JJ,4)
      DO 151 J=1,10
      IF(EXIT.GT.0.)GO TO 151
      XWATER=WATER
      WATER=WATER-H2OCAP+SOILW(J)
      IF(WATER.GT.0.)GO TO 152
      SOILW(J)=SOILW(J)+XWATER
      EXIT=1.
      GO TO 151
  152 SOILW(J)=H2OCAP
  151 CONTINUE
      GO TO 175
  154 H2ORUN=H2ORUN+H2OEXC
      DO 155 J=1,10
  155 SOILW(J)=H2OCAP
  175 EXIT=0.
      PANVAP=CLIMAT(JJ,5)
      K=10
      DO 178 J=1,10
      QH2O=SOILW(J)
      IF(EXIT.GT.0.)GO TO 178
      IF(SOILW(J).GT.0.)GO TO 176
      K=K-1
      IF(K.LE.0)K=1
      GO TO 178
  176 KMOIST=((K*5)+5)/10
      PANVAP=PANVAP*ESUBT(KMOIST)
      SOILW(J)=SOILW(J)-PANVAP
      IF(SOILW(J).GT.0.)GO TO 177
      PANVAP=PANVAP-QH2O
      NSW=KMOIST
      GO TO 178
  177 EXIT=1.
      NSW=KMOIST
      PANVAP=0.
  178 CONTINUE
      STRESS=XSTRES(EVAP,NSW)
      RETURN
      END
```

```
MCKIN*TF.D
      SUBROUTINE PHZDAZ(   CLIMAT,DAYFAC,NYTFAC,DAYLNG,        IOLD,
     1TDAY,TNYT,DAYTYM,NYTTYM,TFACD,TFACN,NEWDAY,TAVG)
C     DAYFAC IS FRACTION ABOVE MINTEMP FOR DAILY TEMP. AVG.
C     NYTFAC IS FRACTION ABOVE MINTEMP FOR NIGHT TEMP. AVG.
C     SUBROUTINE PHZDAZ CALCULATES THE LENGTH OF THE PHYSIOLOGICAL DAY A
C     BASED ON THE ESTIMATED AVERAGE TEMPERATURE OF EACH, DEG.CENTIGRADE
C     IOLD=PHYSIOLOGICAL TIME,DEGREE-DAYS FROM START OF PLANT GROWTH
      DIMENSION CLIMAT(300,7),PCOT(200,9)
```

PROGRAM LISTING—Continued

```
      COMMON /COM/FR,DAY,I,JJ,PCOT,ISTSQR
      REAL NYTFAC,MAXMIN,        NYTT,NYTTYM
      INTEGER FR(45,8 )
      IF(CLIMAT(JJ,2).GT.30.)CLIMAT(JJ,2)=30.
      MAXMIN= CLIMAT(JJ,2)-CLIMAT(JJ,3)
      TDAY=MAXMIN*DAYFAC+CLIMAT(JJ,3)
      TNYT=MAXMIN*NYTFAC+CLIMAT(JJ,3)
      TFACD=(TDAY-12.)/14.
      IF(TDAY.LT.12.)TFACD=0.
      TFACN=(TNYT-12.)/14.
      IF(TNYT.LT.12.)TFACN=0.
      DAYT=TFACD*DAYLNG
      DAYTYM=DAYT/24.
      NYTT=TFACN*(24.-DAYLNG)
      NYTTYM=NYTT/24.
       TAVG=(TDAY+TNYT)/2.
      DAYINC=DAYTYM+NYTTYM
   20 DAY=DAY+DAYINC
      I=(DAY*10.+5.)/10.
      IF(I.LT.1)I=1
      NEWDAY=I-IOLD
      IOLD=I
      RETURN
      END
```

```
MCKIN*TF.E
      SUBROUTINE PNET(LAI,CLIMAT,POPFAC,PLANTW,DAYTYM,NYTTYM,RSUBO,
     1PN,STRESS,TDAY,LYTRES,GSUBR,CO2,EFF,ROWSP,NMIN,LCONC)
C     THIS SUBROUTINE CALCULATES NET PHOTOSYNTHESIS(PN) PER DAY PER PLT.
C     CLIMAT IS RADIATION PER DAY
C     DAYTYM AND NYTTYM ARE LENGTHS OF DAY AND NIGHT IN PHYSIOLOGICAL
C     TIME
C     PTSRED IS THE FACTOR BY WHICH LEAF WILTING REDUCES THE RATE OF
C     PHOTOSYNTHESIS
C     RSUBL=COEFFICIENT FOR LIGHT RESPIRATION
C     RSUBO=COEFFICIENT FOR MAINTENANCE RESPIRATION
C     GSUBR=VEGETATION RESPIRATION COEFFICIENT
      DIMENSION CLIMAT(300,7),PCOT(200,9)
      REAL LAI,NYTTYM,LYTCPT,LYTRES
      INTEGER CO2,FR(45,8 )
      COMMON /COM/FR,DAY,I,JJ,PCOT,ISTSQR
      COMMON  STMWT,ROOTWT
      REAL LCONC,NMIN(5)
      FNIT=0.75+(0.25/0.012)*(LCONC-NMIN(1))
      IF(FNIT.LT..75)FNIT=0.75
      IF(FNIT.GT.1.0)FNIT=1.0
      Z=2.263-0.19859*(CLIMAT(JJ,6)-129.)+0.016169*((CLIMAT(JJ,6)-129.)*
     1*2)
      LYTCPT=1.0756+Z/ROWSP
      IF(LYTCPT.GE.1.)LYTCPT=1.
      IF(STRESS.LT.10.)PTSRED=.1
      IF(STRESS.LT.9.)PTSRED=.25
      IF(STRESS.LT.8.)PTSRED=.5
      IF(STRESS.LT.7.)PTSRED=.8
      IF(STRESS.LT.6.)PTSRED=1.
      WATTSM=CLIMAT(JJ,1)*.8942
      PSTAND=2.3908+1.37379*WATTSM-0.00054136*(WATTSM**2)
      PPLANT=PSTAND*LYTCPT*POPFAC*PTSRED*0.001
      PPLANT=PPLANT*1.06*EFF*FNIT
      CO2=CLIMAT(JJ,7)
      IF(CO2.EQ.1)PPLANT=PPLANT*1.405
C     CO2 IS A CO2 FERTILIZATION TRIGGER, WHEN EQUAL
C    1, PPLANT IS INCREASED 20% DUE TO 500 PPM CO2.
      RSUBL=0.0032125+0.0066875*TDAY
      LYTRES=RSUBL*PPLANT
      BMAIN=PLANTW*RSUBO*(DAYTYM+NYTTYM)
      PTS=PPLANT-LYTRES-BMAIN
      IF(PTS.LE..01)PTS=0.01
      PN=PTS/(1.+GSUBR)
      RETURN
      END
```

PROGRAM LISTING—Continued

```
MCKIN*TF.F
      SUBROUTINE QPREQZ(PQLEFD,PQLEFN,PQSTMD,PQSTMN,PQRTSD,PQRTSN,PQBOLD
     1,PQBOLN,PQRESN,PQFLR,PBOLL,NYTTYM,DAYTYM,PQBOLX,TFACD,TFACN,TOPRES
     2,PRES,RESADD,NEWDAY,LEFWT,SUMLEF,SUMSTM,SUMRTS,INOD,NONOD,
     3NOBR,FAGE,NVEG,NBRV,FRV,FAGV,NFL,ADD,NSTRES)
C     THIS SUBROUTINE CALCULATES THE PHOTOSYNTHATE REQUIRED FOR STANDARD
C     GROWTH BY EACH PART OF THE PLANT ON THE DATE BASED ON THE GROWTH
C     OF THE STANDARD PLANT ON THE SAME DAY
C     PQLEFD,PQLEFN, ETC.  ARE THE STANDARD REQUIREMENTS FOR DAY (D) AND
C     NIGHT (N) FOR LEAF (LEF) GROWTH, STEM (STM) GROWTH, ETC.
C     PQBOLD IS BOLL REQUIREMENT,PQRESN IS REQUIREMENT FOR REBUILDING
C     DEPLETED RESERVES,PQFLR IS THE METABOLIC COST OF A FLOWER
      REAL NYTTYM,LEFADD,LEFWT,        PCOT(200,9),PBOLL(60)
      INTEGER FRV(30,5),FAGV(30,5)
      INTEGER FR(45,8 ),FAGE(45,8 )
      COMMON /COM/FR,DAY,I,JJ,PCOT,ISTSQR
      COMMON  STMWT,ROOTWT
      XYN=NSTRES
      REDN=1.-0.4*XYN
      IF(REDN.LE.0.)REDN=0.
      LEFADD=ADD
      SUMLEF=SUMLEF+PCOT(I,5)*LEFADD
      SUMSTM=SUMSTM+PCOT(I,3)
      SUMRTS=SUMRTS+PCOT(I,1)
      QUAN=30000./20498.
      PCOT(I,5)=PCOT(I,5)*QUAN
      IF(I.GT.42)GO TO 15
      PCOT(I,3)=PCOT(I,3)*QUAN
      PCOT(I,1)=PCOT(I,1)*QUAN
      GO TO 16
15    CONTINUE
      PCOT(I,3)=(.2+.06*STMWT)*QUAN
      PCOT(I,1)=(.02+.006*ROOTWT)*QUAN
16    CONTINUE
      PQLEFN=PCOT(I,5)*NYTTYM*LEFADD
      PQLEFD=PCOT(I,5)*DAYTYN*LEFADD
      PQSTMD=PCOT(I,3)*DAYTYM
      PQSTMN=PCOT(I,3)*NYTTYM
      PQRTSD=PCOT(I,1)*    DAYTYM
      PQRTSN=PCOT(I,1)*    NYTTYM
      PQBOLD=0.
      PQBOLN=0.
      PQRESN=(TOPRES-PRES)*RESADD
      IF(I.LE.ISTSQR+ 28)GO TO 11
      DO 10 L=INOD,NONOD
      DO 10 M=1,NOBR
      NAGE=FAGE(L,M)- 28+   6
      IF(NAGE.LT.1) GO TO 10
      IF(FR(L,M).EQ.1)GO TO 8
      IF(FR(L,M).NE.2)GO TO 10
      IF(NAGE.GT.  60)GO TO 10
8     CONTINUE
      PQBOLD=PBOLL(NAGE)*DAYTYM+PQBOLD
      PQBOLN=PBOLL(NAGE)*NYTTYM+PQBOLN
   10 CONTINUE
      DO 12 LV=3,NVEG
      DO 12 MV=1,NBRV
      NAGE=FAGV(LV,MV)- 28+   6
      IF(NAGE.LT.1) GO TO 12

      IF(FRV(LV,MV).EQ.1)GO TO 9
      IF(FRV(LV,MV).NE.2)GO TO 12
      IF(NAGE.GT.  60)GO TO 12
9     CONTINUE
      PQBOLD=PBOLL(NAGE)*DAYTYM+PQBOLD
      PQBOLN=PQBOLN+PBOLL(NAGE)*NYTTYM
   12 CONTINUE
11    CONTINUE
      PQBOLX=PQBOLD+PQBOLN
      IF(PQBOLX.LE.0)NFL=1
      IF(PQBOLX.GT.0)NFL=0
      IF(PQBOLX.LE.0.)PQBOLX=1.
      RETURN
      END
```

PROGRAM LISTING—Continued

```
MCKIN*TF.G
      SUBROUTINE PQDAYZ(STRESS,STRLMT,PQLEFD,PQSTMD,PQRTSD,PQBOLD,TRES,P
     1RES,PN,RESUFC,LEFWT,XTRES,TRNSLF,LEAFW,STMW,ROTW)
C     PQDAYZ COMPUTES THE PHOTOSYNTHATE USED FOR PLANT GROWTH FOR THE D*
      DIMENSION FR(45,8 )
      DIMENSION  PCOT(200,9)
      COMMON /COM/FR,DAY,I,JJ,PCOT,ISTSQR
      COMMON  STMWT,ROOTWT
      INTEGER XTRES
      REAL LEAFW
      REAL LEFWT
      LEAFW=LEFWT
      XTRES=0
      ROTW=ROOTWT
      STMW=STMWT
      TRESXX=PN*TRNSLF
      PN=PN-TRESXX
      IF(STRESS.GT.STRLMT) GO TO 41
      PREQ=PQLEFD+PQSTMD+PQBOLD+PQRTSD
      IF(PREQ.GT.PN)GO TO 40
C     NO STRESS ON PLANT
      TRES=PN-PREQ
   50 LEFWT=LEFWT+PQLEFD
      STMWT=STMWT+PQSTMD
      ROOTWT=ROOTWT+PQRTSD
      GO TO 200
   40 PAVAIL=PN+TRES+PRES*RESUFC
      XTRES=3
      IF(PREQ.GT.PAVAIL)GO TO 60
      IF(PREQ.GT.PN+TRES)GO TO 70
C     USES TEMPORARY  RESERVES AND PN ONLY
      TRES=PN+TRES-PREQ
      GO TO 50
   70 PRES=PRES-PREQ+PN+TRES
C     ALL TEMP. RESERVES ARE USED AS WELL AS SOME PERMANENT RESERVES
      TRES=0.
      GO TO 50
   41 PREQ=PQBOLD+PQRTSD
      IF(PREQ.GT.PN)GO TO 42
C     WATER STRESS ONLY
      TRES=PN-PREQ
   51 ROOTWT=ROOTWT+PQRTSD
      GO TO 200
   42 PAVAIL=PN+TRES+PRES*RESUFC
      XTRES=3
      IF(PREQ.GT.PAVAIL) GO TO 61
      IF(PREQ.GT.PN+TRES)GO TO 72
C     PLANT USES PN AND TEMP. RESERVES ONLY
      TRES=PN+TRES-PREQ
      GO TO 51
   72 PRES=PRES-PREQ+PN+TRES
C     PLANT DIPS INTO PERMANENT RESERVES
      TRES=0.
      GO TO 51
   61 TRES=0.
C     CARBOHYDRATE STRESS AND MOISTURE STRESS
      PRES=PRES-PRES*RESUFC
      F=PAVAIL/PREQ
C     F=RATIO OF AVAIL PN TO REQUIRED
      IF(F.LT..5)XTRES=3
      ROOTWT=ROOTWT+PQRTSD*F
      PQBOLD=PQBOLD*F
      GO TO 200
   60 TRES=0.
C     CARBOHYDRATE STRESS ONLY
      PRES=PRES-PRES*RESUFC
      F=PAVAIL/PREQ
      LEFWT=LEFWT+PQLEFD*F
      STMWT=STMWT+PQSTMD*F
      PQBOLD=PQBOLD*F
  200 CONTINUE
      PN=0.
      TRES=TRES+TRESXX
      RETURN
      END
```

PROGRAM LISTING—Continued

```
MCKIN*TF.H
          SUBROUTINE PQNYTZ(PQLEFN,PQSTMN,PQRTSN,PQBOLN,PQRESN,PQFLR,TRES,
         1LEFWT,PRES,TOPRES,HISTD,LOSTD,XTRES,LEFSTF,POLYNA,RES
         1UFC,        PN,TOPRSF,STRESS,RFALL)
C         POLYNA (POLLINATE) IF GIVEN A VALUE SIGNALS THAT A BOLL MAY BE SET
C         PQNYTZ CALCULATES THE PHOTOSYNTHATE REQUIRED FOR PLANT PARTS FOR T
C         WILL OCCUR BASED ON THE CALCULATED CARBOHYDRATE STRESS OR LACK OF
C         NIGHT AND COMPUTES THE  WEIGHT GAINS. IT ALSO  COMPUTES WHETHER BO
C         IF A BLOOM IS PRESENT
          DIMENSION FR(45,8 )
          DIMENSION  PCOT(200,9)
          COMMON /COM/FR,DAY,I,JJ,PCOT,ISTSQR
          COMMON  STMWT,ROOTWT
          INTEGER POLYNA,XTRES
          REAL          LEFWT,LOSTD,LEFSTF
          TOPRES=STMWT*TOPRSF
          POLYNA=1.0
          XTRES=0
          PRESX=PRES
          TSLIMT=LEFWT*LEFSTF
          IF(TRES.GT.TSLIMT)TRES=TSLIMT
          IF(PRESX.LE.0.)PRESX=.001
          PREQ=PQLEFN+PQSTMN+PQRTSN+PQBOLN+PQRESN+PQFLR
          IF(PREQ.GT.TRES)GO TO 210
          TRES=TRES-PREQ
      230 ROOTWT=ROOTWT+PQRTSN
      250 LEFWT=LEFWT+PQLEFN
          STMWT=STMWT+PQSTMN
          PRES=PRES+PQRESN
          IF(PRES.GT.TOPRES)GO TO 231
      232 IF(TRES.LT.HISTD)GO TO 600
          POLYNA=1.
          GO TO 600
      231 TRES=TRES+PRES-TOPRES
          PRES=TOPRES
          GO TO 232
      210 PAVAIL=TRES+PRES*RESUFC
          IF(PREQ.GT.PAVAIL)GO TO 220
          PRES=PRES-PREQ+TRES
          TRES=0.
          ABC=(PRESX-PRES)/PRESX
          IF(ABC.LT.LOSTD)GO TO 221
          GO TO 230
      221 POLYNA=1.0
          GO TO 230
      220 TRES=0.
          PRES=PRES-PRES*RESUFC
          PREQ2=PREQ-PQRTSN
          IF(PREQ2.GT.PAVAIL)GO TO 240
          ROOTWT=ROOTWT+(PAVAIL-PREQ2)
          GO TO 250
      240 STQN=PQLEFN+PQSTMN+PQBOLN+PQRESN+PQFLR
          F=PAVAIL/STQN
          IF(F.LE..8)XTRES=1
          IF(F.LE..6)XTRES=2
          IF(F.LE..4)XTRES=3
          IF(F.LE..1)XTRES=4
          LEFWT=LEFWT+PQLEFN*F
          STMWT=STMWT+PQSTMN*F
          PQBOLN=PQBOLN*F
          PRES=PRES+PQRESN*F
      600 CONTINUE
          IF(RFALL.GT.0.5)POLYNA=0.
          RETURN
          END
```

```
MCKIN*TF.I
          SUBROUTINE NITR(RDEP,POM,EFN,TEMN,NMAX,NMIN,    ROWSP,PERN,POPPLT,
         1NPART,NSTRES,RESN,DREQN,DEFCIT,USE,LCONC,H2ODEF,H2OCAP,GBLOS,
         2LEFWT,COTXX,GRCOTX,R,JJK,FRVL,WS,WR)
          INTEGER FR(45,8 )
          DIMENSION PCOT(200,9)
          COMMON /COM/FR,DAY,I,JJ,PCOT,ISTSQR
          COMMON STMWT,ROOTWT
```

PROGRAM LISTING—Continued

```
      INTEGER FRVL
      REAL NMAX(5),NMIN(5),NPART(5),LCONC,LEFR,LEFWT,LEFRS,LEFR1
      DATA APPL/0./,WLEF/0./,WSTM/0./,WGRCOT/0./,WROT/0./,SCON/0./
      DATA BCON/0./,WCOTX/0./
C    NITROGEN SUBROUTINE FOR SIMCOT II
      BURR=0.
      DEFCIT=0.
      SEEDR=0.
      COTTON=(COTXX+GRCOTX)
      EXC=0.
      GRGR=COTTON-(WGRCOT+WCOTX)
      XN=.0515*20000./POPPLT
      NSTRES=0
      CW=ROWSP
      CD=30.48
      CL=(43560./ROWSP/POPPLT)*(30.48**2)
      VTOT=CW*CD*CL
      AW=(1./42.)*30.48*(JJ+7)
      AL=AW
      AD=(1./28.)*30.48*(JJ+7)
      IF(AW.GT.CW) AW=CW
      IF(AL.GT.CL)AL=CL
      IF(AD.GT.CD)AD=CD
      VPLT=AW*AD*AL
      PERN=(VPLT/VTOT)*74.5*POM/POPPLT
      PERN=PERN*(1.-(H2ODEF/(H2OCAP*10.))**2)
      TEMN=TEMN+(VTOT-VPLT)*74.5*POM/(POPPLT*VTOT)
C     CARDS INSERTED IF SIDE DRESSED, FORM AS FOLLOWS
      IF(JJ.EQ.40)APPL=66.7
      IF(APPL.LT.1.) GO TO 1
      IF(R.LT.0.05) GO TO 1
      TEMN=TEMN+(APPL*EFN*453.6)/POPPLT
      APPL=0.
    1 XNUP=XN
      USE=0.
      SUPR=1.
      SEEDR=NMAX(2)*COTTON*0.416-NPART(2)
      BURR=NMAX(3)*COTTON*0.278-NPART(3)
   22 LEFR=NMAX(1)*LEFWT-NPART(1)
      STMR=NMAX(4)*STMWT-NPART(4)
      ROTR=NMAX(4)*ROOTWT-NPART(5)
      IF(LEFR.LT.0.) LEFR=0.
      IF(SEEDR.LT.0.) SEEDR=0.
      IF(BURR.LT.0.) BURR=0.
      IF(STMR.LT.0.) STMR=0.
      IF(ROTR.LT.0.) ROTR=0.
      DREQN=SEEDR+LEFR+BURR+STMR+ROTR
      SEEDR1=NMAX(2)*GRGR*0.416
      LEFR1=NMAX(1)*(LEFWT-WLEF)
      IF(LEFR1.LT.0)LEFR1=0.
C     BURMIN=MIN. NITR. REQ FOR BUR GROWTH
      BURMIN=NMIN(3)*GRGR*0.278
      BURR1=(NMAX(3)-NMIN(3))*GRGR*0.278
      STMR1=NMAX(4)*(STMWT-WSTM)
      ROTR1=NMAX(4)*(ROOTWT-WROT)
      BOL1=BURMIN+SEEDR1
      IF(BOL1.LE.0.) BOL1=0.000001
      REQ1=LEFR1+SEEDR1+BURR1+STMR1+ROTR1+BURMIN
      IF(H2ODEF.GT.0.5*H2OCAP*10.)XNUP=XN*0.9
      IF(H2ODEF.GT.0.6*H2OCAP*10.)XNUP=XN*0.8
      IF(H2ODEF.GT.0.8*H2OCAP*10.)XNUP=XN*0.6
      IF(H2ODEF.GT.0.9*H2OCAP*10.)XNUP=XN*0.4
      IF(H2ODEF.GT..95*H2OCAP*10.)XNUP=XN*0.2
      IF(PERN+TEMN.LT.XNUP) XNUP=PERN+TEMN
      XNUP1=XNUP
      IF( REQ1.GT.XNUP)GO TO 2
      IF(REQ1.LE.0.0) REQ1=0.
      IF(RSQ1.LT.XNUP)GO TO 10
      XNUF=REQ1
      GO TO 3
    2 IF(XNUP.LT.BOL1   ) GO TO 6
      SUPR=(XNUP-BOL1   )/(REQ1-BOL1   )
      IF(SUPR.LT..000001)SUPR=.000001
      NSTRES=1
    3 IF(PERN.GE.XNUP) GO TO 4
      IF(PERN+TEMN.GE.XNUP) GO TO 5
      IF(PERN+TEMN.LT.BOL1   ) GO TO 6
```

PROGRAM LISTING—Continued

```
      SUPR1=(PERN+TEMN-BOL1   )/(REQ1-BOL1   )
      IF(SUPR1.LT.SUPR) SUPR=SUPR1
      IF(SUPR.LT..000001)SUPR=.000001
      NSTRES=1
    5 TEMN=TEMN-XNUP+PERN
      IF(TEMN.LT.0.0) TEMN=0.
    4 NPART(1)=LEFR1*SUPR+NPART(1)
      IF(NPART(1).LT..0001) NPART(1)=.0001
      NPART(2)=NPART(2)+SEEDR1
      IF(NPART(2).LT..0001) NPART(2)=.0001
      NPART(3)=NPART(3)+BURMIN
      NPART(3)=NPART(3)+BURR1*SUPR
      IF(NPART(3).LT..0001) NPART(3)=.0001
      NPART(4)=STMR1*SUPR+NPART(4)
      IF(NPART(4).LT..0001) NPART(4)=.0001
      NPART(5)=ROTR1*SUPR+NPART(5)
      IF(NPART(5).LT..0001) NPART(5)=.0001
      GO TO 20
    6 DEFCIT=BOL1   -XNUP
      IF(RESN.GT.0.) GO TO 7
      NSTRES=3
      IF(DEFCIT/BOL1.GT.0.67) NSTRES=4
      NPART(2)=NPART(2)+XNUP*SEEDR1/BOL1
      IF(NPART(2).LT..0001) NPART(2)=.0001
      NPART(3)=NPART(3)+XNUP*BURMIN/BOL1
      IF(NPART(3).LT..0001) NPART(3)=.0001
      TEMN=TEMN-XNUP+PERN
      IF(TEMN.LT.0.) TEMN=0.
      GO TO 20
    7 NPART(2)=NPART(2)+SEEDR1
      IF(NPART(2).LT..0001) NPART(2)=.0001
      NPART(3)=NPART(3)+BURMIN
      IF(NPART(3).LT..0001) NPART(3)=.0001
      NPART(1)=NPART(1)-DEFCIT*LEFRS/RESN
      IF(NPART(1).LT..0001) NPART(1)=.0001
      NPART(4)=NPART(4)-DEFCIT*STMRS/RESN
      IF(NPART(4).LT..0001) NPART(4)=.0001
      NPART(5)=NPART(5)-DEFCIT*ROTRS/RESN
      IF(NPART(5).LT..0001) NPART(5)=.0001
      TEMN=TEMN-XNUP+PERN
      NSTRES=2
      USE=(DEFCIT-RESN)/BOL1
      IF(USE.GT..1)NSTRES=3
      IF(USE.GT.0.90)NSTRES=4
      IF(TEMN.LE.XNUP) TEMN=0.
      GO TO 20
   10 IF(DREQN.GT.REQ1) EXC=XNUP1-REQ1
      IF(DREQN.LT.XNUP1.AND.EXC.GT.0.) EXC=DREQN-REQ1
      TEMN=TEMN-EXC-REQ1+PERN
      IF(TEMN.LT.0.) TEMN=0.
      IF((DREQN-SEEDR).LE.0.0) GO TO 20
      NPART(2)=NPART(2)+SEEDR1
      IF(NPART(2).LT..0001) NPART(2)=.0001
      NPART(1)=NPART(1)+EXC*LEFR/(DREQN-SEEDR)+LEFR1
      IF(NPART(1).LT..0001) NPART(1)=.0001
      NPART(3)=NPART(3)+EXC*BURR/(DREQN-SEEDR)+BURR1
      IF(NPART(3).LT..0001) NPART(3)=.0001
      NPART(4)=NPART(4)+EXC*STMR/(DREQN-SEEDR)+STMR1
      IF(NPART(4).LT..0001) NPART(4)=.0001
      NPART(5)=NPART(5)+EXC*ROTR/(DREQN-SEEDR)+ROTR1
      IF(NPART(5).LT..0001) NPART(5)=.0001
20    STMWT=STMWT+WS
      ROOTWT=ROOTWT+WR
      LEFRS=NPART(1)-NMIN(1)*LEFWT
      STNRS=NPART(4)-NMIN(4)*STMWT
      ROTRS=NPART(5)-NMIN(4)*ROOTWT
      IF(COTXX+GRCOTX.LT.0.01) GO TO 21
      SCON=NPART(2)-GBLOS*NPART(2)/COTTON
      BCON=NPART(3)/(COTTON*0.278)
      IF(BCON.LT..0001) BCON=.0001
      NPART(2)=NPART(2)-GBLOS*NPART(2)/COTTON
      IF(NPART(2).LT..0001) NPART(2)=.0001
      NPART(3)=NPART(3)-GBLOS*NPART(3)/COTTON
      IF(NPART(3).LT..0001) NPART(3)=.0001
   21 STCON=NPART(4)/STMWT
      IF(STCON.LT..0001) STCON=.0001
      RCON=NPART(5)/ROOTWT
```

PROGRAM LISTING—Continued

```
       LCONC=NPART(1)/LEFWT
       IF(LCONC.LT..0001) LCONC=.0001
       IF(LEFRS.LT.0.) LEFRS=0.
       IF(STMRS.LT.0.) STMRS=0.
       IF(ROTRS.LT.0.) ROTRS=0.
       RESN=LEFRS+STMRS+ROTRS
       IF(RESN.LT.0.)RESN=0.
       IF(JJ.NE.JJK)GO TO 80
       WRITE(6,50)LCONC,SCON,BCON,STCON,RCON,NSTRES
 50    FORMAT(' ',' CUNCENTRATIONS ',5F7.4,'   NSTRES=',I2)
       WRITE(6,75)NPART
 75    FORMAT(' ',' NPART(1-5) ',5F8.4)
 80    CONTINUE
    77 WLEF=LEFWT
       WGRCOT=GRCOTX
       WSTM=STMWT-WS
       WCOTX=COTXX
       WROT=ROOTWT-WR
       STMWT=STMWT-WS
       ROOTWT=ROOTWT-WR
       RETURN
       END
```

```
MCKIN*CLMCOT.J
       SUBROUTINE PLTMAP(PBOLL,WTBOLL,TAVG,NEWDAY,PQBOLN,PQBOLD,PQBOLX,
      1XTRES,NOBR1,NONOD,BOLLST,SQLOST,COTXX,GRCOTX,ROWSP,PQFLR,POLYNA,
      2FAGE,INOD,NOBR,POPPLT,NUMGRN,NUMOPN,NVEG,NBRV,FRV,FAGV,WTBOLV,NV
      3,BLOOM,LEAFW,LEFWT,NFL,CLIMAT,  STMW,ROTW,GBLOS,WLOST,NSTRES,JJK)
       DIMENSION CLIMAT(300,7)
       INTEGER JK(45,8)/360*0/,JKV(30,5)/150*0/
       DIMENSION WLOST(3)
       DIMENSION STEMW(200),ROOTW(200)
       COMMON /COM/FR,DAY,I,JJ,PCOT,ISTSQR
       COMMON STMWT,ROOTWT
       REAL LEAFW
       REAL LEFWT
       REAL LEAFWT(200)/200*0./
       INTEGER SQLOST,BOLLST,BLOOM
       INTEGER FRV(30,5),FAGV(30,5)
       DATA AVTEMP/0./,ISQ/0/,TMAIN/0./
       REAL  TMPV(30)/30*0./,DSV(30)/30*0./
       INTEGER  NTLV(30)/30*0/
       REAL       TBRV(30)/30*0./,WTBOLV(30,5)
       INTEGER  XTRES,FR(45,8 ),NTL(45)/45*0/,FAGE(45,8 ),POLYNA
       REAL       PCOT(200,9),PBOLL(60),WTBOLL(45,8 ),DSQ(45)/45*0./,
      1TAVL(45)/45*0./,T(45)/45*0./
       IF(NSTRES.EQ.1)NSTRES=0
       ROOTW(JJ)=ROOTWT-ROTW
       LAST=0
       GBLOS=0.
       STEMW(JJ)=STMWT-STMW
       IF(JJ.LE.24)GO TO 8000
       STMWT=STMWT-STEMW(JJ-24)
       ROOTWT=ROOTWT-ROOTW(JJ-24)
       WLOST(1)=STEMW(JJ-24)
       WLOST(2)=ROOTW(JJ-24)
 8000  CONTINUE
       PQFLR=0.
       XTRES=0
       LEAFWT(JJ)=LEFWT-LEAFW
       XM=0.0529-(2.147*POPPLT)/(10.**7)
       NOBR=2.0+XM*ROWSP+1.
 C     THE '+1.' IS ADDED TO NOBR TO ACCOUNT FOR THE MAIN STEM NODE
 C     WHERE THE BRANCH IS ATTACHED.
       IF(ISQ.EQ.1)GO TO 3
       IF(I.GE.31)GO TO 1
 C     AVTEMP IS ACCUMULATED AVG TEMP FOR FIRST 31 DAYS
       AVTEMP=((JJ-1)*AVTEMP+TAVG)/JJ
       RETURN
     1 IF(AVTEMP.LE.27.)GO TO 2
       ISQ=1
       ISTSQR=I  +(AVTEMP-27.)*3.
       INOD=6.+1.333*(AVTEMP-27.)
       NONOD=INOD
```

PROGRAM LISTING—Continued

```
               GO TO 3
             2 ISTSQR=I
               ISQ=1
               INOD=7
               NONOD=INOD
             3 IF(I.GE.ISTSQR)GO TO 4
               RETURN
             4 IF(I.GT.ISTSQR)GO TO 5
               NVEG=30
               NBRV=4.5-0.00002895*POPPLT+1
               FRLST=0
               FRLSTV=0
               IF(NBRV.LT.1)NBRV=1
               TV=I+2.5
               NV=1
               TBRV(1)=I+6.0
               DSV(1)=JJ
               DO 6 L=1,INOD
               IF(LAST.EQ.1)GO TO 6
               FR(L,1)=4
               FAGE(L,1)=1
             6 CONTINUE
               TMAIN=I   +2.5
               T(INOD)=I   +6.0
               DSQ(INOD)=JJ
               NONOD=INOD
               NOBR1=2
               IF(LAST.EQ.1)GO TO 5
               FR(INOD,2)=1
               FRV(1,1)=4
     5         IF(NEWDAY.EQ.0)GO TO 7
               COTXX=0.
               GRCOTX=0.
               NUMGRN=0
               NUMOPN=0
               BLOOM=0.
     7         BOLINC      =(PQBOLD+PQBOLN)/PQBOLX
               IF(NFL.EQ.1)GO TO 901
               IF(BOLINC      .LE..85)XTRES=1
               IF(BOLINC      .LE..6)XTRES=2
               IF(BOLINC      .LE..35)XTRES=3
               IF(BOLINC      .LE..2)XTRES=4
   901         CONTINUE
               IF(NEWDAY.EQ.0)GO TO 630
               DO 610 L=1,NONOD
               DO 610 M=1,NOBR1
               IF(FR(L,M).EQ.0) GO TO 610
               FAGE(L,M)=FAGE(L,M)+1
               IF(FR(L,M).NE.1)GO TO 8
               IF(FAGE(L,M).NE. 28)GO TO 8
               IF(LAST.EQ.1)GO TO 8
               PQFLR=PQFLR+PCOT(I,7)
               IF(POLYNA.EQ.1)GO TO 9
               FR(L,M)=4
               BLOOM=BLOOM+1.
               GO TO 8
             9 FR(L,M)=2
             8 CONTINUE
               IF(FR(L,M).NE.2) GO TO 12
               IF(FAGE(L,M).NE.76) GO TO 10
               IF(LAST.EQ.1)GO TO 10
               FR(L,M)=3
            10 CONTINUE
               IF(JJ.EQ.JJK.AND.LAST.EQ.1.AND.FR(L,M).EQ.2.AND.FAGE(L,M).LT.28)
              1FAGE(L,M)=28
               NAGE=FAGE(L,M)- 28
               IF(NAGE.LT.1)GO TO 610
               IF(NAGE.GT.60  )NAGE=60
               IF(FR(L,M).NE.2) GO TO 12
               NUMGRN=NUMGRN+1
               WTBOLL(L,M)=WTBOLL(L,M)+PBOLL(NAGE)*BOLINC
               GRCOTX=GRCOTX+WTBOLL(L,M)
               GO TO 610
            12 IF(FR(L,M).NE.3) GO TO 610
               NUMOPN=NUMOPN+1
               COTXX=COTXX+WTBOLL(L,M)
           610 CONTINUE
```

PROGRAM LISTING—Continued

```
      DO 710 LV=3,NVEG
      DO 710 MV=1,NBRV
      IF(FRV(LV,MV).EQ.0) GO TO 710
      FAGV(LV,MV)=FAGV(LV,MV)+1
      IF(FRV(LV,MV).NE.1) GO TO 78
      IF(FAGV(LV,MV).NE. 28)GO TO 78
      IF(LAST.EQ.1)GO TO 78
      IF(POLYNA.EQ.1) GO TO 79
      PQFLR=PQFLR+PCOT(I,7)
      FRV(LV,MV)=4
      BLOOM=BLOOM+1.
      GO TO 76
   79 FRV(LV,MV)=2
   78 CONTINUE
      IF(FRV(LV,MV).NE.2) GO TO 82
      IF(FAGV(LV,MV).NE.76) GO TO 80
      IF(LAST.EQ.1)GO TO 80
      FRV(LV,MV)=3
   80 CONTINUE
      IF(JJ.EQ.JJK.AND.LAST.EQ.1.AND.FRV(LV,MV).EQ.2.AND.FAGV(LV,MV).LT.
     128)FAGV(LV,MV)=28
      NAGE=FAGV(LV,MV)- 28
      IF(NAGE.LT.1) GO TO 710
      IF(NAGE.GT.60  )NAGE=60
      IF(FRV(LV,MV).NE.2) GO TO 82
      NUMGRN=NUMGRN+1
      WTBOLV(LV,MV)=WTBOLV(LV,MV)+PBOLL(NAGE)*BOLINC
      GRCOTX=GRCOTX+WTBOLV(LV,MV)
      GO TO 710
   82 IF(FRV(LV,MV).NE.3) GO TO 710
      NUMOPN=NUMOPN+1
      COTXX=COTXX+WTBOLV(LV,MV)
  710 CONTINUE
  630 CONTINUE
      IF(JJ.EQ.JJK.AND.LAST.EQ.1)I=TMAIN
      IF(I.LT.TMAIN)GO TO 14
      TMAIN=TMAIN+2.5
      NONOD=NONOD+1
      T(NONOD)=I  +6.0
      DSQ(NONOD)=JJ
      IF(LAST.EQ.1)GO TO 14
      FR(NONOD,1)=4
      FR(NONOD,2)=1
C       BURNING PINHEAD SQUARES
      IF(CLIMAT(JJ,1).GE.700.)FR(NONOD,2)=4
      FAGE(NONOD 1)=1
   14 CONTINUE
      DO 15 L=INOD,NONOD
      TAVL(L)=(TAVL(L)*(JJ-DSQ(L))+TAVG)/(JJ-DSQ(L)+1)
      IF(I.LT.T(L))GO TO 15
      IF(NTL(L).EQ.1)GO TO 20
      T(L)=T(L)+0.333*(30.-TAVL(L))
      NTL(L)=1
   20 IF(I.LT.T(L))GO TO 15
      NTL(L)=0
      TAVL(L)=0.
      DSQ(L)=JJ
      ICNOD=0
      DO 16 M=1,NOBR
      IF(ICNOD.GT.0)GO TO 16
      IF(FR(L,M).GT.0) GO TO 16
      ICNOD=1
      T(L)=I+6.0
      IF(LAST.EQ.1)GO TO 17
      FR(L,M)=1
C       BURNING PINHEAD SQUARES
      IF(CLIMAT(JJ,1).GE.700.)FR(L,M)=4
      FAGE(L,M)=1
17    CONTINUE
      IF(L.NE.INOD) GO TO 16
      NOBR1=NOBR1+1
   16 CONTINUE
   15 CONTINUE
      IF(NV.GE.NVEG) GO TO 90
      IF(JJ.EQ.JJK.AND.LAST.EQ.1)I=TV
      IF(I.LT.TV) GO TO 90
      TV=TV+2.5
```

PROGRAM LISTING—Continued

```
      NV=NV+1
      IF(LAST.EQ.1)GO TO 900
      FRV(NV,1)=4
900   CONTINUE
      IF(NV.LT.3)GO TO 802
      IF(LAST.EQ.1)GO TO 90
      FRV(NV,2)=1
C      BURNING PINHEAD SQUARES
      IF(CLIMAT(JJ,1).GE.700.)FRV(NV,2)=4
      TBRV(NV)=I+6.0
800   FAGV(NV,1)=1
   90 CONTINUE
      IF(NV.LT.3)GO TO 802
      DO 95 LV=3,NV
      TMPV(LV)=(TMPV(LV)*(JJ-DSV(LV))+TAVG)/(JJ-DSV(LV)+1.)
      IF(I.LT.TBRV(LV)) GO TO 95
      IF(NTLV(LV).EQ.1) GO TO 97
      NTLV(LV)=1
      TBRV(LV)=TBRV(LV)+0.333*(30.-TMPV(LV))
   97 IF(I.LT.TBRV(LV)) GO TO 95
      TBRV(LV)=TBRV(LV)+6.0
      NTLV(LV)=0
      TMPV(LV)=0.
      DSV(LV)=JJ
      IVNOD=0
      DO 96 MV=1,NBRV
      IF(IVNOD.GT.0) GO TO 96
      IF(FRV(LV,MV).GT.0) GO TO 96
      IVNOD=1
      IF(LAST.EQ.1)GO TO 95
      FRV(LV,MV)=1
C      BURNING PINHEAD SQUARES
      IF(CLIMAT(JJ,1).GE.600.)FRV(LV,MV)=4
      FAGV(LV,MV)=1
   96 CONTINUE
   95 CONTINUE
802   CONTINUE
      SQLOST=0.
      BOLLST=0.
      XYN=NSTRES
      TMAIN=TMAIN+1.33*XYN/4.
      TV=TV+1.33*XYN/3.
      IF(LAST.EQ.1)GO TO 1000
      DO 1002 L=INOD,NONOD
      DO 1002 M=1,NOBR
      IF(FR(L,M).EQ.5.AND.JK(L,M).EQ.JJ)GO TO 1001
      IF(FR(L,M).EQ.6.AND.JK(L,M).EQ.JJ)GO TO 1003
      GO TO 1002
1001  FR(L,M)=4
      SQLOST=SQLOST+1
      GO TO 1002
1003  FR(L,M)=4
      BOLLST=BOLLST+1
      GRCOTX=GRCOTX-WTBOLL(L,M)
      GBLOS=GBLOS+WTBOLL(L,M)
      WTBOLL(L,M)=0.
1002  CONTINUE
1000  CONTINUE
      IF(LAST.EQ.1)GO TO 2000
      DO 2002 MV=1,NBRV
      DO 2002 LV=1,NVEG
      IF(FRV(LV,MV).EQ.5.AND.JKV(LV,MV).EQ.JJ)GO TO 2001
      IF(FRV(LV,MV).EQ.6.AND.JKV(LV,MV).EQ.JJ)GO TO 2003
      GO TO 2002
2001  FRV(LV,MV)=4
      SQLOST=SQLOST+1
      GO TO 2002
2003  FRV(LV,MV)=4
      BOLLST=BOLLST+1
      GRCOTX=GRCOTX-WTBOLV(LV,MV)
      GBLOS=GBLOS+WTBOLV(LV,MV)
      WTBOLV(LV,MV)=0.
2002  CONTINUE
2000  CONTINUE
      IF(XTRES.LE.0..AND.NSTRES.EQ.0)GO TO 125
      DO 114 L=INOD,NONOD
      T(L)=T(L)+1.33*XYN/4.
```

PROGRAM LISTING—Continued

```
       IF(XTRES.EQ.4)T(L)=T(L)+1.50
       IF(XTRES.EQ.3)T(L)=T(L)+1.20
       IF(XTRES.EQ.2)T(L)=T(L)+0.60
       IF(XTRES.EQ.1)T(L)=T(L)+0.20
       IF(LAST.EQ.1)GO TO 1140
       DO 114 M=1,NOBR
       IF(FR(L,M).NE.1)GO TO 119
       IF(XTRES.EQ.0)GO TO 119
       GO TO (109,110,111,112),XTRES
109    IF(FAGE(L,M).GE.12..AND.FAGE(L,M).LE.12.)GO TO 113
       GO TO 114
110    IF(FAGE(L,M).GE.12..AND.FAGE(L,M).LE.12.)GO TO 113
       GO TO 114
111    IF(FAGE(L,M).GE.9.0.AND.FAGE(L,M).LE.12.)GO TO 113
       GO TO  114
112    IF(FAGE(L,M).GE.8.0.AND.FAGE(L,M).LE.13.)GO TO 113
       GO TO  114
113    CONTINUE
       FR(L,M)=5
       JK(L,M)=JJ+8
       GO TO  114
  119  CONTINUE
       IF(NSTRES.EQ.0)GO TO 114
       GO TO (114,116,117,118),NSTRES
118    IF(FR(L,M).EQ.2.AND.FAGE(L,M).LE.38)GO TO 120
       IF(FR(L,M).EQ.1.AND.FAGE(L,M).LE.6)GO TO 114
117    IF(FR(L,M).EQ.2.AND.FAGE(L,M).LE.33)GO TO 120
116    IF(FR(L,M).EQ.1.AND.FAGE(6,M).LE.3)GO TO 114
       GO TO 114
120    CONTINUE
       FR(L,M)=6
       JK(L,M)=JJ+8
  114  CONTINUE
1140   CONTINUE
       DO 214 LV=1,NVEG
       TBRV(LV)=TBRV(LV)+1.33*XYH/3.
       IF(XTRES.EQ.4)TBRV(LV)=TBRV(LV)+1.50
       IF(XTRES.EQ.3)TBRV(LV)=TBRV(LV)+1.20
       IF(XTRES.EQ.2)TBRV(LV)=TBRV(LV)+0.60
       IF(XTRES.EQ.1)TBRV(LV)=TBRV(LV)+0.20
       IF(LAST.EQ.1)GO TO 2140
       DO 214 MV=1,NBRV
       IF(FRV(LV,MV).NE.1)GO TO 219
       IF(XTRES.EQ.0)GO TO 219
       GO TO (209,210,211,212),XTRES
209    IF(FAGV(LV,MV).GE.12..AND.FAGV(LV,MV).LE.12.)GO TO 213
       GO TO 214
210    IF(FAGV(LV,MV).GE.12..AND.FAGV(LV,MV).LE.12.)GO TO 213
       GO TO 214
211    IF(FAGV(LV,MV).GE.9.0.AND.FAGV(LV,MV).LE.12.)GO TO 213
       GO TO  214
212    IF(FAGV(LV,MV).GE.8.0.AND.FAGV(LV,MV).LE.13.)GO TO 213
       GO TO  214
213    CONTINUE
       FRV(LV,MV)=5
       JKV(LV,MV)=JJ+8
       GO TO 214
219    CONTINUE
       IF(NSTRES.EQ.0)GO TO 214
       GO TO (214,216,217,218),NSTRES
218    IF(FRV(LV,MV).EQ.2.AND.FAGV(LV,MV).LE.38)GO TO 220
       IF(FRV(LV,MV).EQ.1.AND.FAGV(LV,MV).LE.6)GO TO 214
       GO TO 214
217    IF(FRV(LV,MV).EQ.2.AND.FAGV(LV,MV).LE.33)GO TO 220
216    IF(FRV(LV,MV).EQ.1.AND.FAGV(LV,MV).LE.3)GO TO 214
       GO TO  214
220    CONTINUE
       FRV(LV,MV)=6
       JKV(LV,MV)=JJ+8
214    CONTINUE
2140   CONTINUE
       IF(XTRES.EQ.0)GO TO 126
       GO TO (130,131,132,133),XTRES
133    TMAIN=TMAIN+1.0
       TV=TV+1.0
       GO TO 126
  2    TMAIN=TMAIN+.7
```

PROGRAM LISTING--Continued

```
          TV=TV+.7
          GO TO 126
  131     TMAIN=TMAIN+.4
          TV=TV+.4
          GO TO 126
  130     TMAIN=TMAIN+0.0
          TV=TV+0.0
      126 CONTINUE
      125 CONTINUE
          IF(JJ.LE.71)GO TO 2141
          LEFWT=LEFWT-LEAFWT(JJ-70)
          WLOST(3)=LEAFWT(JJ-70)
  2141    CONTINUE
          RETURN
          END
```

PROGRAM LISTING—Continued

```
@DATA,L  COTDA.
DATA006-RLIB69      01/16-16:06:20
        DATA FOR SIMCOT II.THE DATA CONSISTS OF SIX SECTIONS,FOUR OF WHICH ARE
        REQUIRED BY THE PROGRAM FOR PROPER OPERATION.THE OTHER TWO SECTIONS
        MUST BE SUPPLIED BY THE USER TO SIMULATE HIS CROP AT HIS LOCATION.THE
        FOLLOWING DATA ARE AN EXAMPLE WHICH THE USER CAN USE TO CONSTRUCT HIS
        OWN DATA FILE.
        **************************************************************************
        PROGRAM SUPPLIED DATA.
        12345678901234567890123456789012345678901234567890123456789012345678901234567890
        [  PQRTS ][ PQSTM   ][  PQLEF ][PQFLR   ][NOT USED]
         .020      .20        .20       .00       .10
         .020      .20        .20       .00       .05
         .020      .20        .20       .00       .20
         .020      .20        .20       .00       .30
         .020      .20        .20       .00       .40
         .020      .20        .20       .00       .48
         .020      .20        .20       .00       .56
         .020      .20        .20       .00       .64
         .020      .20        .20       .00       .72
         .020      .20        .20       .00       .80
         .030      .30        .30       .00       .92
         .030      .30        .30       .00      1.04
         .030      .30        .30       .00      1.16
         .030      .30        .30       .00      1.28
         .030      .30        .30       .00      1.40
         .050      .50        .32       .00      1.56
         .050      .50        .32       .00      1.72
         .050      .50        .32       .00      1.88
         .050      .50        .32       .00      2.04
         .050      .50        .32       .00      2.20
         .080      .80        .48       .00      2.46
         .080      .80        .48       .00      2.72
         .080      .80        .48       .00      2.98
         .080      .80        .48       .00      3.24
         .080      .80        .48       .00      3.50
         .060      .60        .40       .00      3.70
         .060      .60        .40       .00      3.90
         .060      .66        .40       .00      4.10
         .060      .60        .40       .00      4.30
         .060      .60        .40       .00      4.50
         .080      .80        .60       .00      4.76
         .080      .80        .60       .00      5.02
         .080      .80        .60       .00      5.28
         .080      .80        .60       .00      5.54
         .080      .80        .60       .00      5.80
         .080      .80        .60       .00      5.80
         .080      .80        .60       .00      5.80
         .080      .80        .60       .00      5.80
         .080      .80        .60       .00      5.80
         .080      .80        .60       .00      5.80
         .080      .80        .60       .50      5.80
        **************************************************************************
        PROGRAM SUPPLIED DATA .THE FOLLOWING IS THE PBOLL DATA.
         .040 .040 .050 .060 .070 .100 .225 .225 .225 .225 .225 .225 .225 .225 .225 .225
         .225 .225 .225 .225 .225 .225 .225 .225 .225 .225 .215 .200 .195 .190 .175 .160
         .150 .130 .120 .110 .100 .095 .080 .075 .070 .060 .050 .040 .035 .030 .027 .020
         .015 .010 .009 .007 .005 .004 .002 .001
        **************************************************************************
        USER SUPPLIED DATA.SUPPLY TITLE.
            WEATHER FOR COPIAH COUNTY,MISS. ,1972
        SUPPLY NUMBER OF DAYS OF WEATHER DATA IN DATA.
             187
        **************************************************************************
        SUPPLY WEATHER DATA FOR GROWING SEASON.
        12345678901234567890123456789012345678901234567890123456789012345678901234567890
        [  SOLAR ][  TMAX  ][  TMIN  ][  RFALL ][  EVAP  ][ DAY NO ][  CO2 T ]
            138.00     80.00     54.00                .06    119.00
            468.00     80.00     54.00                .01    120.00
            443.00     80.00     54.00                .15    121.00
            405.00     86.00     57.00                .20    122.00
            208.00     78.00     60.00      1.53      .20    123.00
            608.00     79.00     59.00       69       .06    124.00
            698.00     77.00     47.00                .25    125.00
            589.00     80.00     52.00                .22    126.00
            484.00     81.00     50.00                .19    127.00
            584.00     76.00     64.00       .10      .18    128.00
            584.00     81.00     65.00       .58      .04    129.00
            658.00     76.00     60.00                .15    130.00
            631.00     74.00     53.00                .22    131.00
            446.00     70.00     66.00                .22    132.00
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PROGRAM LISTING—Continued

```
000080    212.00   69.00   64.00    .06    .19   133.00
000081    658.00   81.00   60.00    .80    .09   134.00
000082    663.00   80.00   60.00           .19   135.00
000083    698.00   79.00   56:00    .02    .28   136.00
000084    647.00   86.00   54.00           .28   137.00
000085    547.00   92.00   60.00           .27   138.00
000086    656.00   77.00   55.00           .21   139.00
000087    661.00   78.00   58.00           .26   140.00
000088    645.00   87.00   56.00           .33   141.00
000089    657.00   87.00   56.00           .28   142.00
000090    641.00   91.00   61.00           .29   143.00
000091    648.00   90.00   65.00           .25   144.00
000092    635.00   90.00   73.00           .30   145.00
000093    663.00   88.00   61.00           .27   146.00
000094    596.00   90.00   59.00           .33   147.00
000095    596.00   88.00   62.00           .25   148.00
000096    596.00   89.00   60.00           .29   149.00
000097    395.00   90.00   61.00           .24   150.00
000098    692.00   89.00   59.00           .16   151.00
000099    638.00   81.00   57.00           .32   152.00
000100    706.00   86.00   50.00           .25   153.00
000101    707.00   79.00   46.00           .24   154.00
000102    690.00   90.00   54.00           .28   155.00
000103    685.00   89.00   55.00           .26   156.00
000104    630.00   91.00   54.00           .28   157.00
000105    643.00   91.00   60.00           .28   158.00
000106    515.00   97.00   65.00           .26   159.00
000107    532.00   94.00   65.00           .32   160.00
000108    396.00   93.00   62.00           .23   161.00
000109    493.00   92.00   69.00           .20   162.00
000110    515.00   90.00   65.00           .23   163.00
000111    623.00   90.00   68.00    .04    .22   164.00
000112    410.00   92.00   68.00           .27   165.00
000113    301.00   91.00   69.00    .05    .17   166.00
000114    396.00   92.00   66.00    .13    .11   167.00
000115    352.00   89.00   70.00    .24    .11   168.00
000116    656.00   90.00   70.00    .07    .09   169.00
000117    648.00   91.00   71.00           .23   170.00
000118    652.00   89.00   69.00           .28   171.00
000119    657.00   95.00   65.00           .33   172.00
000120    548.00   91.00   68.00    .34    .36   173.00
000121    326.00   92.00   61.00           .20   174.00
000122    301.00   90.00   62.00    .23    .17   175.00
000123    545.00   92.00   71.00           .10   176.00
000124    241.00   89.00   68.00           .22   177.00
000125    584.00   93.00   72.00    .91    .12   178.00
000126    607.00   94.00   73.00           .26   179.00
000127    554.00   93.00   75.00           .36   180.00
000128    215.00   90.00   70.00           .29   181.00
000129    370.00   94.00   68.00   1.53    .08   182.00
000130    602.00   92.00   68.00    .19    .21   183.00
000131    635.00   93.00   73.00           .26   184.00
000132    260.00   93.00   69.00    .11    .28   185.00
000133    278.00   89.00   67.00    .26    .19   186.00
000134    659.00   77.00   67.00    .15    .11   187.00
000135    669.00   81.00   59.00           .25   188.00
000136    692.00   85.00   57.00           .25   189.00
000137    508.00   86.00   55.00           .23   190.00
000138    611.00   89.00   59.00           .18   191.00
000139    551.00   88.00   65.00           .19   192.00
000140    614.00   91.00   63.00           .22   193.00
000141    630.00   92.00   66.00           .27   194.00
000142    568.00   85.00   63.00    .61    .27   195.00
000143    533.00   89.00   67.00    .58    .27   196.00
000144    461.00   90.00   65.00           .24   197.00
000145    598.00   93.00   70.00           .20   198.00
000146    499.00   88.00   68.00    .83    .28   199.00
000147    627.00   90.00   67.00    .45    .20   200.00
000148    663.00   92.00   96.00           .24   201.00
000149    601.00   89.00   68.00    .35    .28   202.00
000150    490.00   91.00   68.00    .02    .27   203.00
000151    671.00   94.00   66.00           .19   204.00
000152    547.00   95.00   70.00           .25   205.00
000153    516.00   94.00   68.00    .02    .22   206.00
000154    551.00   95.00   72.00           .27   207.00
000155    604.00   93.00   71.00           .27   208.00
000156    582.00   93.00   73.00    .50    .29   209.00
000157    561.00   92.00   73.00    .05    .28   210.00
000158    240.00   85.00   70.00           .30   211.00
000159    434.00   84.00   69.00   1.74    .12   212.00
000160    519.00   89.00   69.00    .68    .15   213.00
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PROGRAM LISTING—Continued

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000161      609.00    90.00    66.00               .05    214.00
000162      492.00    91.00    68.00               .22    215.00
000163      610.00    93.00    68.00               .25    216.00
000164      623.00    93.00    70.00               .26    217.00
000165      626.00    92.00    70.00               .27    218.00
000166      646.00    92.00    69.00               .25    219.00
000167      635.00    95.00    74.00               .34    220.00
000168      589.00    92.00    74.00               .33    221.00
000169      556.00    95.00    73.00               .27    222.00
000170      461.00    93.00    68.00               .30    223.00
000171      441.00    96.00    67.00               .19    224.00
000172      370.00    94.00    66.00               .23    225.00
000173      356.00    91.00    68.00       .09     .18    226.00
000174      532.00    93.00    68.00               .15    227.00
000175      550.00    89.00    68.00       .25     .24    228.00
000176      480.00    92.00    67.00               .27    229.00
000177      521.00    93.00    68.00               .24    230.00
000178      504.00    92.00    68.00               .25    231.00
000179      566.00    96.00    69.00               .24    232.00
000180      498.00    98.00    70.00               .24    233.00
000181      412.00    99.00    73.00               .29    234.00
000182      439.00    97.00    77.00               .28    235.00
000183      509.00    95.00    68.00               .33    236.00
000184      259.00    96.00    68.00               .21    237.00
000185      402.00    94.00    68.00       .41     .22    238.00
000186      319.00    94.00    69.00       .05     .13    239.00
000187      586.00    93.00    68.00               .16    240.00
000188      584.00    89.00    61.00               .27    241.00
000189      551.00    91.00    62.00               .25    242.00
000190      520.00    92.00    61.00               .22    243.00
000191      460.00    95.00    63.00               .23    244.00
000192      385.00    92.00    69.00               .19    245.00
000193      478.00    95.00    67.00       .03     .19    246.00
000194      435.00    96.00    65.00               .18    247.00
000195      270.00    96.00    67.00               .24    248.00
000196      262.00    90.00    70.00               .13    249.00
000197      514.00    93.00    63.00               .12    250.00
000198      472.00    96.00    73.00               .19    251.00
000199      522.00    98.00    72.00               .22    252.00
000200      495.00    95.00    73.00               .24    253.00
000201      539.00    95.00    68.00               .30    254.00
000202      401.00    91.00    69.00               .21    255.00
000203      485.00    96.00    72.00               .15    256.00
000204      514.00    96.00    61.00               .20    257.00
000205      530.00    97.00    65.00               .30    258.00
000206      503.00    99.00    64.00               .26    259.00
000207      286.00    94.00    67.00               .24    260.00
000208      365.00    96.00    66.00      1.43     .12    261.00
000209      518.00    96.00    69.00       .02     .15    262.00
000210      483.00    94.00    70.00               .23    263.00
000211      478.00    95.00    67.00       .44     .21    264.00
000212      399.00    91.00    66.00               .20    265.00
000213      200.00    90.00    68.00      1.31     .16    266.00
000214      355.00    91.00    68.00       .62     .05    267.00
000215      238.00    90.00    66.00               .13    268.00
000216      162.00    88.00    72.00               .13    269.00
000217      361.00    87.00    67.00               .08    270.00
000218      343.00    88.00    70.00       .45     .17    271.00
000219      365.00    89.00    70.00       .29     .18    272.00
000220      387.00    87.00    69.00      1.22     .12    273.00
000221      544.00    78.00    57.00               .34    274.00
000222      528.00    72.00    41.00               .19    275.00
000223      518.00    78.00    43.00               .15    276.00
000224      458.00    78.00    54.00               .17    277.00
000225      409.00    88.00    65.00       .02     .14    278.00
000226      410.00    87.00    65.00               .17    279.00
000227      355.00    85.00    58.00               .17    280.00
000228      391.00    76.00    64.00               .17    281.00
000229      385.00    78.00    52.00               .09    282.00
000230      395.00    81.00    52.00               .12    283.00
000231      400.00    87.00    51.00               .12    284.00
000232      432.00    86.00    55.00               .17    285.00
000233      409.00    86.00    55.00               .14    286.00
000234      361.00    89.00    58.00               .14    287.00
000235      416.00    90.00    59.00               .14    288.00
000236      339.00    81.00    66.00               .17    289.00
000237      402.00    86.00    53.00               .15    290.00
000238      393.00    90.00    67.00               .15    291.00
000239      351.00    89.00    67.00               .16    292.00
000240      104.00    78.00    50.00       .13     .26    293.00
000241      376.00    70.00    37.00       .03     .05    294.00
```

```
    271.00     75.00     51.00                 .08    295.00
     43.00     78.00     61.00                 .07    296.00
    346.00     79.00     65.00     1.75        .11    297.00
    141.00     67.00     52.00       .02       .15    298.00
     81.00     60.00     39.00                 .11    299.00
     34.00     57.00     38.00                 .03    300.00
    262.00     65.00     52.00       .55       .07    301.00
     84.00     69.00     48.00                 .02    302.00
     71.00     73.00     52.00                 .03    303.00
     72.00     82.00     54.00                 .08    304.00
    172.00     86.00     66.00                 .00    305.00
**************************************************************************
PROGRAM SUPPLIED DATA.TABLE OF DECLINATION VALUES FOR SUN.
12345678901234567890123456789012345678901234567890123456789012345678901234567890
-2304               -2242               -2213               -2137
-2054               -2005               -1909               -1808          -1719
               -1610               -1455               -1337               -1215
               -1050               - 923               - 753               - 621
               - 448               - 304               - 139               - 005
                 130                 304            414                 546
            717                 846                1012                1135
           1256                1413      1450                1602
 1709                1811                1909                2002
 2049                2130           2157                2228                2252
                2310                2322                2327                2325
                2317      2310                2252                2228
      2157                2121                2039                1950
      1857           1814                1712                1606
 1455                1341                1223                1102
  936            835                 707                 537                 406
                 234                 101                 032               - 206
     - 253               - 426               - 558               - 729
     - 858               -1025               -1150               -1312
-1411               -1527               -1638               -1745
-1848               -1945               -2036               -2121          -2141
          -2216               -2245               -2306               -2320
          -2326               -2325               -2317
PROGRAM SUPPLIED DATA.TABLE OF WATER STRESS VALUES.
12345678901234567890123456789012345678901234567890123456789012345678901234567890
   .5   .0   .0   .0   .0  2.5   .2   .0   .0   .0  5.0  2.0   .5   .0   .0
  6.8  4.0  2.2  1.0   .5  7.7  5.6  4.0  2.7  2.0  8.7  7.2  6.0  5.0  4.5
  9.0  8.5  7.2  6.5  6.0
**************************************************************************
USER SUPPLIED DATA.USER MUST FURNISH THE FOLLOWING DATA TO SIMULATE HIS CROP.
12345678901234567890123456789012345678901234567890123456789012345678901234567890
[LATITUDE][SEASON L][SOIL CAP][ EMERGE ][ ROWSP  ][  LEFADD][ PH EFF ][ POPPLT ]
        34       170      1.69       125     101.6      1.35       1.0    41000.
[  POM   ][  EFN   ][INITIALN][ RESIDN ]
       1.0      0.60      20.0      30.0
THE FOLLOWING DATA IS USED BY THE PROGRAM TO VARY THE AMOUNT OF OUTPUT
REQUESTED.JJK-FIRST DAY PRINTED OUT.LAST-EQUAL TO ZERO FOR RUN WITHOUT
MANUAL UPDATING.JB-INCREMENT ADDED TO JJK TO OUTPUT DATA.



[JJK][LAST][ JB ]
   10    0   10
```

EXAMPLE RUNS

The user of SIMCOT II must employ a data file as illustrated in this manual. Two examples are given. In both examples all the data are the same except for the last line of the data file.

Cotton Growth Simulation Run

Data input: SIMCOT II data file, with emphasis on last line as follows:

```
JJK LAST JB            ← Variables
12345678901234567890   ← Column count
10     0   10          ← The data
```

To execute the program, the user must compile in FORTRAN, map, and execute the absolute element. The data are added to the runstream after the execute command with proper job control language. Given below is the output of SIMCOT II with the above data file as input to the program. Notice that the plant is listed every 10th day; however, this can be changed by the user to suit his needs by changing only the last data card.

The normal output in this case prints the plant out in graphical form. The following symbols indicate plant parts: X, square; *, green boll; #, open boll; 0, abscised site or main-stem node; I, fruiting-branch internode; and =, main-stem internode.

Various parameters are also printed out. All are self-explanatory except "concentrations" and "NPART (1–5)." The concentrations are the concentrations of nitrogen by percent in the leaves, seed, burrs, stems, and roots. NPART (1–5) is the nitrogen accumulation by weight in leaves (1), seed (2), burr (3), stems (4), and roots (5).

INPUT DATA

```
@DATA,L  CLMDATA.,CLMDATA.
DATA006-RLIB67-10  12/05-13:26:31
000001          .020          .20          .20          .00          .10
000002          .020          .20          .20          .00          .05
000003          .020          .20          .20          .00          .20
000004          .020          .20          .20          .00          .30
000005          .020          .20          .20          .00          .40
000006          .020          .20          .20          .00          .48
000007          .020          .20          .20          .00          .56
000008          .020          .20          .20          .00          .64
000009          .020          .20          .20          .00          .72
000010          .020          .20          .20          .00          .80
000011          .030          .30          .30          .00          .92
000012          .030          .30          .30          .00         1.04
000013          .030          .30          .30          .00         1.16
000014          .030          .30          .30          .00         1.28
000015          .030          .30          .30          .00         1.40
000016          .050          .50          .32          .00         1.56
000017          .050          .50          .32          .00         1.72
000018          .050          .50          .32          .00         1.88
000019          .050          .50          .32          .00         2.04
000020          .050          .50          .32          .00         2.20
000021          .080          .80          .48          .00         2.46
000022          .080          .80          .48          .00         2.72
000023          .080          .80          .48          .00         2.98
000024          .080          .80          .48          .00         3.24
000025          .080          .80          .48          .00         3.50
000026          .060          .60          .40          .00         3.70
000027          .060          .60          .40          .00         3.90
000028          .060          .66          .40          .00         4.10
000029          .060          .60          .40          .00         4.30
000030          .060          .60          .40          .00         4.50
000031          .080          .80          .60          .00         4.76
000032          .080          .80          .60          .00         5.02
000033          .080          .80          .60          .00         5.28
000034          .080          .80          .60          .00         5.54
000035          .080          .80          .60          .00         5.80
000036          .080          .80          .60          .00         5.80
000037          .080          .80          .60          .00         5.80
000038          .080          .80          .60          .00         5.80
000039          .080          .80          .60          .00         5.80
000040          .080          .80          .60          .00         5.80
000041          .080          .80          .60          .50         5.80
000042          .040 .040 .050 .060 .070 .100 .225 .225 .225 .225 .225 .225 .225 .225 .225 .225
000043          .225 .225 .225 .225 .225 .225 .225 .225 .225 .225 .215 .200 .195 .190 .175 .160
000044          .150 .130 .120 .110 .100 .095 .080 .075 .070 .060 .050 .040 .035 .030 .027 .020
000045          .15 .010 .009 .007 .005 .004 .002 .001
000046               WEATHER FOR COPIAH COUNTY,MISS. ,1972
```

INPUT DATA—Continued

```
000047             187
000048          138.00     80.00     54.00                 .06    119.00
000049          468.00     80.00     54.00                 .01    120.00
000050          443.00     80.00     54.00                 .15    121.00
000051          405.00     86.00     57.00                 .20    122.00
000052          208.00     78.00     60.00        1.53     .20    123.00
000053          608.00     79.00     59.00          69     .06    124.00
000054          698.00     77.00     47.00                 .25    125.00
000055          589.00     80.00     52.00                 .22    126.00
000056          484.00     81.00     50.00                 .19    127.00
000057          584.00     76.00     64.00         .10     .18    128.00
000058          584.00     81.00     65.00         .58     .04    129.00
000059          658.00     76.00     60.00                 .15    130.00
000060          631.00     74.00     53.00                 .22    131.00
000061          446.00     70.00     66.00                 .22    132.00
000062          212.00     69.00     64.00         .06     .19    133.00
000063          658.00     81.00     60.00         .80     .09    134.00
000064          663.00     80.00     60.00                 .19    135.00
000065          698.00     79.00     56.00         .02     .28    136.00
000066          647.00     86.00     54.00                 .28    137.00
000067          547.00     82.00     60.00                 .27    138.00
000068          656.00     77.00     55.00                 .21    139.00
000069          661.00     78.00     58.00                 .26    140.00
000070          645.00     87.00     56.00                 .33    141.00
000071          657.00     87.00     56.00                 .28    142.00
000072          641.00     91.00     61.00                 .29    143.00
000073          648.00     90.00     65.00                 .25    144.00
000074          635.00     90.00     73.00                 .30    145.00
000075          663.00     88.00     61.00                 .27    146.00
000076          596.00     90.00     59.00                 .33    147.00
000077          596.00     88.00     62.00                 .25    148.00
000078          596.00     89.00     60.00                 .29    149.00
000079          395.00     90.00     61.00                 .24    150.00
000080          692.00     89.00     59.00                 .16    151.00
000081          638.00     81.00     57.00                 .32    152.00
000082          706.00     86.00     50.00                 .25    153.00
000083          707.00     79.00     46.00                 .24    154.00
000084          690.00     90.00     54.00                 .28    155.00
000085          685.00     89.00     55.00                 .26    156.00
000086          630.00     91.00     54.00                 .28    157.00
000087          643.00     91.00     60.00                 .28    158.00
000088          515.00     97.00     65.00                 .26    159.00
000089          532.00     94.00     65.00                 .32    160.00
000090          396.00     93.00     62.00                 .23    161.00
000091          493.00     92.00     69.00                 .20    162.00
000092          515.00     90.00     65.00                 .23    163.00
000093          623.00     90.00     68.00         .04     .22    164.00
000094          410.00     92.00     68.00                 .27    165.00
000095          301.00     91.00     69.00         .05     .17    166.00
000096          396.00     92.00     66.00         .13     .11    167.00
000097          352.00     89.00     70.00         .24     .11    168.00
000098          656.00     90.00     70.00         .07     .09    169.00
000099          648.00     91.00     71.00                 .23    170.00
000100          652.00     89.00     69.00                 .28    171.00
000101          657.00     95.00     65.00                 .33    172.00
000102          548.00     91.00     68.00         .34     .36    173.00
000103          326.00     92.00     61.00                 .20    174.00
000104          301.00     90.00     62.00         .23     .17    175.00
000105          545.00     92.00     71.00                 .10    176.00
000106          241.00     89.00     68.00                 .22    177.00
000107          594.00     93.00     72.00         .91     .12    178.00
000108          607.00     94.00     73.00                 .26    179.00
000109          554.00     93.00     75.00                 .36    180.00
000110          215.00     90.00     70.00                 .29    181.00
000111          370.00     94.00     68.00        1.53     .08    182.00
000112          602.00     92.00     68.00         .19     .21    183.00
000113          635.00     93.00     73.00                 .26    184.00
000114          260.00     93.00     69.00         .11     .28    185.00
000115          278.00     89.00     67.00         .26     .19    186.00
000116          659.00     77.00     67.00         .15     .11    187.00
000117          669.00     81.00     59.00                 .25    188.00
000118          692.00     85.00     57.00                 .25    189.00
000119          508.00     86.00     55.00                 .23    190.00
000120          611.00     89.00     59.00                 .18    191.00
000121          551.00     88.00     65.00                 .19    192.00
000122          614.00     91.00     63.00                 .22    193.00
000123          630.00     92.00     66.00                 .27    194.00
000124          568.00     85.00     63.00         .61     .27    195.00
000125          533.00     89.00     67.00         .58     .27    196.00
000126          461.00     90.00     65.00                 .24    197.00
000127          598.00     93.00     70.00                 .20    198.00
```

INPUT DATA—Continued

000128	499.00	88.00	68.00	.83	.28	199.00
000129	627.00	90.00	67.00	.45	.20	200.00
000130	663.00	92.00	96.00		.24	201.00
000131	601.00	89.00	68.00	.35	.28	202.00
000132	490.00	91.00	68.00	.02	.27	203.00
000133	671.00	94.00	66.00		.19	204.00
000134	547.00	95.00	70.00		.25	205.00
000135	516.00	94.00	68.00	.02	.22	206.00
000136	551.00	95.00	72.00		.27	207.00
000137	604.00	93.00	71.00		.27	208.00
000138	582.00	93.00	73.00	.50	.29	209.00
000139	561.00	92.00	73.00	.05	.28	210.00
000140	240.00	85.00	70.00		.30	211.00
000141	434.00	84.00	69.00	1.74	.12	212.00
000142	519.00	89.00	69.00	.60	.15	213.00
000143	609.00	90.00	66.00		.05	214.00
000144	492.00	91.00	68.00		.22	215.00
000145	610.00	93.00	68.00		.25	216.00
000146	623.00	93.00	70.00		.26	217.00
000147	626.00	92.00	70.00		.27	218.00
000148	646.00	92.00	69.00		.25	219.00
000149	635.00	95.00	74.00		.34	220.00
000150	589.00	92.00	74.00		.33	221.00
000151	556.00	95.00	73.00		.27	222.00
000152	461.00	93.00	68.00		.30	223.00
000153	441.00	96.00	67.00		.19	224.00
000154	370.00	94.00	66.00		.23	225.00
000155	356.00	91.00	68.00	.09	.18	226.00
000156	532.00	93.00	68.00		.15	227.00
000157	550.00	89.00	68.00	.25	.24	228.00
000158	480.00	92.00	67.00		.27	229.00
000159	521.00	93.00	68.00		.24	230.00
000160	504.00	92.00	68.00		.25	231.00
000161	566.00	96.00	69.00		.24	232.00
000162	498.00	98.00	70.00		.24	233.00
000163	412.00	99.00	73.00		.29	234.00
000164	439.00	97.00	77.00		.28	235.00
000165	509.00	95.00	68.00		.33	236.00
000166	259.00	96.00	68.00		.21	237.00
000167	402.00	94.00	68.00	.41	.22	238.00
000168	319.00	94.00	69.00	.05	.13	239.00
000169	586.00	93.00	68.00		.16	240.00
000170	584.00	89.00	61.00		.27	241.00
000171	551.00	91.00	62.00		.25	242.00
000172	520.00	92.00	61.00		.22	243.00
000173	460.00	95.00	63.00		.23	244.00
000174	385.00	92.00	69.00		.19	245.00
000175	478.00	95.00	67.00	.03	.19	246.00
000176	435.00	96.00	65.00		.18	247.00
000177	270.00	96.00	67.00		.24	248.00
000178	262.00	90.00	70.00		.13	249.00
000179	514.00	93.00	63.00		.12	250.00
000180	472.00	96.00	73.00		.19	251.00
000181	522.00	98.00	72.00		.22	252.00
000182	495.00	95.00	73.00		.24	253.00
000183	539.00	95.00	68.00		.30	254.00
000184	401.00	91.00	69.00		.21	255.00
000185	485.00	96.00	72.00		.15	256.00
000186	514.00	96.00	61.00		.20	257.00
000187	530.00	97.00	65.00		.30	258.00
000188	503.00	99.00	64.00		.26	259.00
000189	286.00	94.00	67.00		.24	260.00
000190	365.00	96.00	66.00	1.43	.12	261.00
000191	518.00	96.00	69.00	.02	.15	262.00
000192	483.00	94.00	70.00		.23	263.00
000193	478.00	95.00	67.00	.44	.21	264.00
000194	399.00	91.00	66.00		.20	265.00
000195	200.00	90.00	68.00	1.31	.16	266.00
000196	355.00	91.00	68.00	.62	.05	267.00
000197	238.00	90.00	66.00		.13	268.00
000198	162.00	88.00	72.00		.13	269.00
000199	361.00	87.00	67.00		.08	270.00
000200	343.00	88.00	70.00	.45	.17	271.00
000201	365.00	89.00	70.00	.29	.18	272.00
000202	387.00	87.00	69.00	1.22	.12	273.00
000203	544.00	78.00	57.00		.34	274.00
000204	528.00	72.00	41.00		.19	275.00
000205	518.00	78.00	43.00		.15	276.00
000206	458.00	78.00	54.00		.17	277.00
000207	409.00	88.00	65.00	.02	.14	278.00
000208	410.00	87.00	65.00		.17	279.00

INPUT DATA—Continued

```
000209          355.00     85.00     58.00                 .17    280.00
000210          391.00     76.00     64.00                 .17    281.00
000211          385.00     78.00     52.00                 .09    282.00
000212          395.00     81.00     52.00                 .12    283.00
000213          400.00     87.00     51.00                 .12    284,00
000214          432.00     86.00     55.00                 .17    285.00
000215          409.00     86.00     55.00                 .14    286.00
000216          361.00     89.00     58.00                 .14    287.00
000217          416.00     90.00     59.00                 .14    288.00
000218          339.00     81.00     66.00                 .17    289.00
000219          402.00     86.00     53.00                 .15    290.00
000220          393.00     90.00     67.00                 .15    291.00
000221          351.00     89.00     67.00                 .16    292.00
000222          104.00     78.00     50.00       .13       .26    293.00
000223          376.00     70.00     37.00       .03       .05    294.00
000224          271.00     75.00     51.00                 .08    295.00
000225           43.00     78.00     61.00                 .07    296.00
000226          346.00     79.00     65.00     1.75        .11    297.00
000227          141.00     67.00     52.00       .02       .15    298.00
000228           81.00     60.00     39.00                 .11    299.00
000229           34.00     57.00     38.00                 .03    300.00
000230          262.00     65.00     52.00       .55       .07    301.00
000231           84.00     69.00     48.00                 .02    302.00
000232           71.00     73.00     52.00                 .03    303.00
000233           72.00     82.00     54.00                 .08    304.00
000234          172.00     86.00     66.00                 .00    305.00

000235      -2304               -2242               -2213               -2137
000236      -2054               -2005               -1909               -1808          -1719
000237                     -1610               -1455               -1337               -1215
000238                     -1050               - 923               - 753               - 621
000239                     - 448               - 3-4               - 139               - 005
000240                       130                 304            414                 546
000241                  717                 846                1012                1135
000242                .1256                1413      1450                1602
000243       1709                1811                1909                2002
000244       2049                2130           2157                2228                2252
000245                      2310                2322                2327                2325
000246                      2317      2310                2252                2228
000247            2157                2121                2038                1950
000248            1857           1814                1712                1606
000249       1455                1341                1223                1102
000250        936            835                 707                 537                 406
000251                       234                 101               - 032               - 206
000252           - 253               - 426               - 538               - 729
000253           - 858               -1025               -1150               -1312
000254      -1411               -1527               -1638               -1745
000255      -1848               -1945               -2036               -2121     -2141
000256                -2216               -2245               -2306               -2320
000257                -2326               -2325               -2317
000258         .5   .0   .0   .0   .0  2.5   .2   .0   .0   .0  5.0  2.0   .5   .0   .0
000259        6.8  4.0  2.2  1.0   .5  7.7  5.6  4.0  2.7  2.0  8.7  7.2  6.0  5.0  4.5
000260        9.0  8.5  7.2  6.5  6.0
000261              34       170     1.69        125     101.6      1.35       1.0    41000.
000262             1.0      0.60      20.0      30.0
000263  NEW    10    0   10
```

OUTPUT DATA

```
@XQT  CLMCOT.S
      WEATHER FOR COPIAH COUNTY,MISS. ,1972
 CONCENTRATIONS   .0420  .0000  .0000  .0200  .0200  NSTRES= 0
 NPART(1-5)     .0264   .0001   .0001   .0103   .0004
== =
DAY  10  CH2O STRESS 0  H2O STRESS   .0   SOLAR RAD  663.  PLANT WT   1.17
SQUARES LOST  0  BOLLS LOST  0  LAI  .08  PHYSIOL. DAYS   6  BLOOMS LOST  0
LEAF WT   .63  MAINSTEM NODES  0 # SQUARES   0 # GREEN BOLLS  0 # SITES   0


== =
 CONCENTRATIONS   .0420  .0000  .0000  .0200  .0200  NSTRES= 0
 NPART(1-5)     .0473   .0001   .0001   .0177   .0008
== =
DAY  20  CN2O STRESS 0  H2O STRESS   .5   SOLAR RAD  635.  PLANT WT   2.05
SQUARES LOST  0  BOLLS LOST  0  LAI  .14  PHYSIOL. DAYS  13  BLOOMS LOST  0
LEAF WT  1.13  MAINSTEM NODES  0 # SQUARES   0 # GREEN BOLLS  0 # SITES   0


== =
 CONCENTRATIONS   .0420  .0000  .0000  .0180  .0200  NSTRES= 0
 NPART(1-5)     .0885   .0001   .0001   .0339   .0042
== =
DAY  30  CN2O STRESS 0  H2O STRESS  1.0   SOLAR RAD  690.  PLANT WT   4.04
SQUARES LOST  0  BOLLS LOST  0  LAI  .26  PHYSIOL. DAYS  20  BLOOMS LOST  0
LEAF WT  2.11  MAINSTEM NODES  0 # SQUARES   0 # GREEN BOLLS  0 # SITES   0


== =
 CONCENTRATIONS   .0420  .0000  .0000  .0176  .0200  NSTRES= 0
 NPART(1-5)     .1597   .0001   .0001   .0690   .0130
== =
DAY  40  CH2O STRESS 0  H2O STRESS  1.0   SOLAR RAD  410.  PLANT WT   7.95
SQUARES LOST  0  BOLLS LOST  0  LAI  .46  PHYSIOL. DAYS  28  BLOOMS LOST  0
LEAF WT  3.80  MAINSTEM NODES  0 # SQUARES   0 # GREEN BOLLS  0 # SITES   0


== =
 CONCENTRATIONS   .0420  .0000  .0000  .0171  .0190  NSTRES= 0
 NPART(1-5)     .2938   .0001   .0001   .1199   .0186
              X   X
              I   I
==0=0=0=0=0=0=0=0=0=
                I
                X
DAY  50  CH2O STRESS 0  H2O STRESS   .0   SOLAR RAD  301.  PLANT WT  14.04
SQUARES LOST  0  BOLLS LOST  0  LAI  .85  PHYSIOL. DAYS  37  BLOOMS LOST  0
LEAF WT  6.99  MAINSTEM NODES  9 # SQUARES   4 # GREEN BOLLS  0 # SITES   4

      X
      I
==0=0=0=

VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM


 CONCENTRATIONS   .0398  .0000  .0000  .0147  .0117  NSTRES= 0
 NPART(1-5)     .4864   .0001   .0001   .1737   .0122
              X   X
              I   I
              X   X   X   X
              I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I
                X   X   X
                I   I
                X   X
DAY  60  CH2O STRESS 0  H2O STRESS   .5   SOLAR RAD  260.  PLANT WT  22.15
SQUARES LOST  0  BOLLS LOST  0  LAI 1.49  PHYSIOL. DAYS  47  BLOOMS LOST  0
LEAF WT 12.23  MAINSTEM NODES 13 # SQUARES  16 # GREEN BOLLS  0 # SITES  16

      X   X   X
      I   I   I
==0=0=0=0=0=0=0=
        I   I
        X   X

VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM
```

```
 CONCENTRATIONS   .0318  .0000  .0000  .0114  .0097  NSTRES= I
 NPART(1-5)    .6752   .0001   .0001   .2364   .0119
              X   X
              I   I
              X   X   X   X
              I   I   I   I
              X   X   X   X   X
              I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I
                X   X   X   X   X
                I   I   I
                X   X   X
                I
                X
DAY  70  CH20 STRESS 0  H20 STRESS   .5   SOLAR RAD  568.  PLANT WT  37.72
SQUARES LOST  0  BOLLS LOST  0  LAI 2.58  PHYSIOL. DAYS  55  BLOOMS LOST  0
LEAF WT 21.20  MAINSTEM NODES 16 # SQUARES  29 # GREEN BOLLS  0 # SITES  30

      X
      I
      X   X   X   X
      I   I   I   I
==0=0=0=0=0=0=0=0=0=0=
        I   I   I   I
        X   X   X   X
        I
        0

VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM

 CONCENTRATIONS   .0262  .0077  .0072  .0082  .0077  NSTRES= 2
 NPART(1-5)    .7525   .0077   .0009   .2792   .0106
              X   X
              I   I
              X   X   X
              I   I   I
              X   X   X   X   X
              I   I   I   I   I
              *   *   X   X   X   X   X
              I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I
                *   X   X   X   X   X   X
                I   I   I   I   I
                X   X   X   X   X
                I   I   I
                X   X   X
                I
                X
DAY  80  CH20 STRESS 2  H20 STRESS   .5   SOLAR RAD  547.  PLANT WT  54.69
SQUARES LOST  0  BOLLS LOST  0  LAI 3.49  PHYSIOL. DAYS  65  BLOOMS LOST  0
LEAF WT 28.74  MAINSTEM NODES 20 # SQUARES  44 # GREEN BOLLS  4 # SITES  52

      0
      I
      X   X   0
      I   I   I
      *   X   X   X   X   X
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        X   X   X   X   X   X
        I   I
        0   0
        I
        X
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM

 CONCENTRATIONS   .0210  .0781  .0061  .0063  .0079  NSTRES= 2
 NPART(1-5)    .6925   .0781   .0080   .2792   .0106
              X   X
              I   I
              *   0   X
              I   I   I
              *   *   0   0   X
              I   I   I   I   I
              *   *   *   *   0   X   X
              I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0-0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I
                *   *   0   0   0   X   X
                I   I   I   I   I
                *   *   0   X   X
                I   I   I
                0   X   X
                I
                X
DAY  90  CH20 STRESS 3  H20 STRESS   .0   SOLAR RAD  492.  PLANT WT  67.50
SQUARES LOST  0  BOLLS LOST  0  LAI 4.00  PHYSIOL. DAYS  75  BLOOMS LOST  0
LEAF WT 32.93  MAINSTEM NODES 20 # SQUARES  19 # GREEN BOLLS 15 # SITES  52

      0
      I
      0   X   0
      I   I   I
      *   *   *   0   X   X
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        *   0   0   0   X   X
        I   I
        0   0
        I
        X
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM

 CONCENTRATIONS   .0186  .1137  .0037  .0051  .0075  NSTRES= 4
 NPART(1-5)     .6812   .1137   .0110   .2696   .0105
              0   0
              I   I
              *   0   0
              I   I   I
              *   *   0   0   0
              I   I   I   I   I
              *   *   *   *   0   0   0
              I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I
                *   *   0   0   0   0   0
                I   I   I   I   I
                *   *   0   0   0
                I   I   I
                0   0   0
                I
                0
DAY 100  CH20 STRESS 2  H20 STRESS   .5   SOLAR RAD  370.  PLANT WT  74.70
SQUARES LOST  0  BOLLS LOST  0  LAI 4.44  PHYSIOL. DAYS  84  BLOOMS LOST  0
LEAF WT 36.54  MAINSTEM NODES 20 # SQUARES   0 # GREEN BOLLS 15 # SITES  52

      0
      I
      0   0   0
      I   I   I
      *   *   *   0   0   0
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        *   0   0   0   0   0
        I   I
        0   0
        I
        0
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM
```

```
 CONCENTRATIONS    .0175  .1053  .0017  .0043  .0070  NSTRES= 4
 NPART(1-5)     .6851   .1053   .0099   .2694   .0105
              0   0
              I   I
              0   0   0
              I   I   I
              *   0   0   0   0
              I   I   I   I   I
              *   *   0   0   0   0   0
              I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I
                *   *   0   0   0   0   0
                I   I   I   I   I
                0   0   0   0   0
                I   I   I
                0   0   0
                I
                0
DAY 110  CH20 STRESS 1  H20 STRESS  2.2   SOLAR RAD  439.  PLANT WT  83.58
SQUARES LOST   0  BOLLS LOST   0  LAI 4.75  PHYSIOL. DAYS  94  BLOOMS LOST  0
LEAF WT 39.07  MAINSTEM NODES 20 # SQUARES    0 # GREEN BOLLS  7 # SITES  52


      0
      I
      0   0   0
      I   I   I
      *   0   0   0   0   0
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        *   0   0   0   0   0
        I   I
        0   0
        I
        0
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM

 CONCENTRATIONS   .0167  .I195  .0015  .0037  .0067  NSTRES= 4

 NPART(1-5)     .6896   .1195   .0113   .2663   .0108
              0   0
              I   I
              0   0   0
              I   I   I
              *   0   0   0   0
              I   I   I   I   I
              *   *   0   0   0   0   0
              I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I
                *   *   0   0   0   0   0
                I   I   I   I   I
                0   0   0   0   0
                I   I   I
                0   0   0
                I
                0
DAY 120  CH20 STRESS 2  H20 STRESS   .5   SOLAR RAD  385.  PLANT WT  91.90
SQUARES LOST   0  BOLLS LOST   0  LAI 5.01  PHYSIOL. DAYS 103  BLOOMS LOST  0
LEAF WT 41.20  MAINSTEM NODES 20 # SQUARES    0 # GREEN BOLLS  7 # SITES  52


      0
      I
      0   0   0
      I   I   I
      *   0   0   0   0   0
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        *   0   0   0   0   0
        I   I
        0   0
        I
        0
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM
```

OUTPUT DATA—Continued

```
 CONCENTRATIONS    .0165  .1344  .0016  .0032  .0063  NSTRES= 3
 NPART(1-5)     .6923    .1344   .0133   .2643   .0108
              0   0
              I   I
              0   0   0
              I   I   I
              *   0   0   0   0
              I   I   I   I   I
              #   *   0   0   0   0   0
              I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I
                #   *   0   0   0   0   0
                I   I   I   I   I
                0   0   0   0   0
                I   I   I
                0   0   0
                I
                0
DAY 130  CH20 STRESS 1  H20 STRESS   .5   SOLAR RAD  401.  PLANT WT  96.72
SQUARES LOST  0  BOLLS LOST  0  LAI 5.12  PHYSIOL. DAYS 112  BLOOMS LOST  0
LEAF WT 42.08  MAINSTEM NODES 20 # SQUARES   0 # GREEN BOLLS  5 # SITES  52


      0
      I
      0   0   0
      I   I   I
      *   0   0   0   0   0
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        *   0   0   0   0   0
        I   I
        0   0
        I
        0
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM


 CONCENTRATIONS    .0177  .1374  .0017  .0028  .0059  NSTRES= 1
 NPART(1-5)     .6948    .1374   .0140   .2730   .0105
              0   0
              I   I
              0   0   0
              I   I   I
              #   0   0   0   0
              I   I   I   I   I
              #   #   0   0   0   0   0
              I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I
                #   #   0   0   0   0   0
                I   I   I   I   I
                0   0   0   0   0
                I   I   I
                0   0   0
                I
                0
DAY 140  CH20 STRESS 0  H20 STRESS   .0   SOLAR RAD  399.  PLANT WT  98.82
SQUARES LOST  0  BOLLS LOST  0  LAI 4.77  PHYSIOL. DAYS 121  BLOOMS LOST  0
LEAF WT 39.21  MAINSTEM NODES 20 # SQUARES   0 # GREEN BOLLS  0 # SITES  52


      0
      I
      0   0   0
      I   I   I
      #   0   0   0   0   0
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        #   0   0   0   0   0
        I   I
        0   0
        I
        0
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM
```

OUTPUT DATA—Continued

```
 CONCENTRATIONS    .0199  .1374  .0019  .0021  .0052  NSTRES= 0
 NPART(1-5)      .7034   .1374   .0155   .2238   .0095
              0   0
              I   I
              0   0   0
              I   I   I
              #   0   0   0   0
              I   I   I   I   I
              #   #   0   0   0   0   0   X
              I   I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I
                #   #   0   0   0   0   0
                I   I   I   I   I
                0   0   0   0   0
                I   I   I
                0   0   0
                I
                0
DAY 150  CH2O STRESS 0  H2O STRESS   .0   SOLAR RAD  528.  PLANT WT  93.29
SQUARES LOST   0  BOLLS LOST   0  LAI 4.29  PHYSIOL. DAYS 130  BLOOMS LOST   0
LEAF WT 35.28  MAINSTEM NODES 21 # SQUARES   1 # GREEN BOLLS  0 # SITES  53


      0
      I
      0   0   0
      I   I   I
      #   0   0   0   0   0
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        #   0   0   0   0   0
        I   I
        0   0
        I
        0
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM


 CONCENTRATIONS    .0193  .1374  .0020  .0018  .0048  NSTRES= 1
 NPART(1-5)      .7204   .1374   .0161   .2092   .0091
              0   0
              I   I
              0   0   0
              I   I   I
              #   0   0   0   0
              I   I   I   I   I
              #   #   0   0   0   0   0   X   X
              I   I   I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I   I
                #   #   0   0   0   0   0   X
                I   I   I   I   I
                0   0   0   0   0
                I   I   I
                0   0   0
                I
                0
DAY 160  CH2O STRESS 0  H2O STRESS   .0   SOLAR RAD  432.  PLANT WT  94.87
SQUARES LOST   0  BOLLS LOST   0  LAI 4.54  PHYSIOL. DAYS 136  BLOOMS LOST   0
LEAF WT 37.31  MAINSTEM NODES 23 # SQUARES   3 # GREEN BOLLS  0 # SITES  55


      0
      I
      0   0   0
      I   I   I
      #   0   0   0   0   0
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        #   0   0   0   0   0
        I   I
        0   0
        I
        0
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM
```

OUTPUT DATA—Continued

```
CONCENTRATIONS    .0196  .1374  .0021  .0014  .0049  NSTRES= 0
NPART(1-5)      .7409   .1374   .0170   .1743   .0095
              X
              I
              0   0   X
              I   I   I
              0   0   0   X
              I   I   I   I
              #   0   0   0   0   X       X
              I   I   I   I   I   I       I
              #   #   0   0   0   0   0   X   X   X
              I   I   I   I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I   I   I
                #   #   0   0   0   0   0   X   X
                I   I   I   I   I   I       I
                0   0   0   0   0   X       X
                I   I   I   I
                0   0   0   X
                I   I
                0   X
DAY 170  CH2O STRESS 0  H2O STRESS   .0   SOLAR RAD  271.  PLANT WT  94.04
SQUARES LOST  0  BOLLS LOST  0  LAI 4.60  PHYSIOL. DAYS 142  BLOOMS LOST  0
LEAF WT 37.80  MAINSTEM NODES 25 # SQUARES  14 # GREEN BOLLS  0 # SITES  66


      0
      I
      0   0   0
      I   I   I
      #   0   0   0   0   0
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        #   0   0   0   0   0
        I   I
        0   0
        I
        0
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM


 YIELD/ACRE 1.679  EMERGENCE DATE 125.  GROWINGDAYS 172  LATITUDE  34.0
# OF GREEN BOLLS  0  # OF OPEN BOLLS  7  SOIL H2O CAPACITY 1.69
H2O RUN OFF  .48  ROW SPACING  101.6  # OF PLANTS/ACRE  41000.


@BRKPT  PRINT$
```

Insect Damage Experiment

The second way in which SIMCOT II can be used is to directly simulate insect damage by removal (changing the fruiting code) of appropriate fruit. Again the same data file is used with the exception of the last card. This program feature was designed to be used on an on-line interactive basis with a demand or time-share terminal but can be used also with card input in the batch mode.

INPUT DATA

SIMCOT II data file, with emphasis on the last card as follows:

```
   JJB LAST  JB           ← Variables
12345678901234567890      ← Column count
   75    1    0           ← The data
```

In this example, we will simulate bollworm damage in which two squares and three bolls are damaged by bollworms.

Step 1.—Execute program and add data file.

Step 2.—Program stops on the 75th day and asks how many fruit are abscised on day 75.

```
Input:  12345  ← Column count
            1  ← Data
```

Which fruit?

```
Input:  123456789012345  ← Column count
             10    2    4  ← Data
```

The fruit at the tenth main-stem node and first fruiting-branch node is assigned a 4, which is the code for a scar. The reason a 2 is used to indicate the first fruiting-branch node is that the 1 fruiting-branch node is where the fruiting branch is attached to the main stem. The fruit code is as follows: 1 is a square, 2 is a green boll, 3 is a mature boll, and 4 is a scar. On a printout these codes appear as X, *, #, and 0, respectively.

Next the program asks if any fruit on the vegetative branch will be abscised.

```
        Input:   12345  ← Column count
                     0  ← Data
```

Do you want the plant printed out in graphic form?

```
        Input:   12345  ← Column count
                     1  ← Data (for "no")
                     0  ← Data (for "yes")
```

Are there any more data after today? (Are you manually going to abscise any more fruit?)

```
    Input:   12345  ← Column count
                 0  ← Data (program proceeds
                        normally)
                 1  ← Data (program will ask
                        for more abscission
                        data)
```

What is the next output day (day on which more damage will be inflicted or is of special interest to user)?

```
        Input:       JJB  ← Variable
                   12345  ← Column count
                      80  ← Data
```

Step 3.—Abscise square on day 80 on the vegetative branch with the following set of cards:

```
12345678901234567890
  0                    ← No abscission on
                            main stem
  1                    ← Number abscised
                            on vegetative
                            branch
  5    2    4          ← Location on
                            vegetative
                            branch and fruit
                            code
  0                    ← Print plant
  1                    ← More data
 85                    ← Next output day
```

Step 4.—Abscise boll on main stem on day 85 with the following set of cards:

```
12345678901234567890
 1
 9    2    4
 0
 0
 1
90
```

Step 5.—Abscise boll on main stem on day 90 with the following set of cards:

```
12345678901234567890
 1
 8    2    4
 0
 0
 1
95
```

Step 6.—Abscise boll on the main stem on day 95 with the following set of cards:

```
12345678901234567890
  1
  7    2    4
  0
  0
  1
165
```

Step 7.—Print out plants on desired day (in this case on day 105 near the end of the season).

```
12345678901234567890
 0
 0
 0
 0
```

The program with the data file as above and the data outlined in the above example will grow a cotton plant which will lose two squares and three bolls due to insect damage. The program output with the mentioned data now follows.

OUTPUT DATA

```
@XQT  CLMCOT.S
       WEATHER FOR COPIAH COUNTY,MISS. ,1972
  CONCENTRATIONS   .0298  .0006  .0216  .0103  .0078  NSTRES= 1
  NPART(1-5)    .7525   .0006   .0002   .2781   .0106
 HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY   75?
    1
 WHICH FRUIT ON MAIN  BRANCH WILL BE ABSCISED ON DAY   75?
   10    2    4
 HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY   75 ?
    0
 DO YOU WANT PLANT  PRINTED OUT ON DAY   75?
    0
 IS THERE ANY MORE DATA AFTER DAY   75?
    1
              X
              I
              X   X   X
              I   I   I
              X   X   X   X   X
              I   I   I   I   I
              *   X   X   X   X   X
              I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I
                X   X   X   X   X   X
                I   I   I   I
                X   X   X   X
                I   I
                X   X
DAY  75  CH2O STRESS 1  H2O STRESS   .0   SOLAR RAD  627.  PLANT WT  46.32
SQUARES LOST  0  BOLLS LOST  0  LAI 3.07  PHYSIOL. DAYS  60  BLOOMS LOST  0
LEAF WT 25.22  MAINSTEM NODES 18 # SQUARES  38 # GREEN BOLLS  1 # SITES  42

      0
      I
      X   X
      I   I
      X   X   X   X   X
      I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I
        X   X   X   X   X
        I   I
        0   0
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM

THIS IS DAY   75     WHAT IS THE NEXT OUTPUT DAY?
  80
 CONCENTRATIONS   .0262  .0078  .0072  .0082  .0077  NSTRES= 2
 NPART(1-5)    .7524   .0078   .0009   .2792   .0106
HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY   80?
   0
HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY   80 ?
   1
WHICH FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY   80?
   5    2    4
DO YOU WANT PLANT  PRINTED OUT ON DAY   80?
   0
IS THERE ANY MORE DATA AFTER DAY   80?
   1
              X   X
              I   I
              X   X   X
              I   I   I
              X   X   X   X   X
              I   I   I   I   I
              *   *   X   X   X   X   X
              I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I
                *   0   X   X   X   X   X
                I   I   I   I   I
                X   X   X   X   X
                I   I   I
                X   X   X
                I
                X
DAY  80  CH2O STRESS 2  H2O STRESS   .5   SOLAR RAD  547.  PLANT WT  54.75
SQUARES LOST  0  BOLLS LOST  0  LAI 3.50  PHYSIOL. DAYS  65  BLOOMS LOST  0
LEAF WT 28.76  MAINSTEM NODES 20 # SQUARES  43 # GREEN BOLLS  4 # SITES  52
```

```
      0
      I
      X   X   0
      I   I   I
      *   X   X   X   X   X
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        X   X   X   X   X   X
        I   I
        0   0
        I
        X
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM

THIS IS DAY   80      WHAT IS THE NEXT OUTPUT DAY?
  85
 CONCENTRATIONS   .0234  .0304  .0063  .0069  .0077  NSTRES= 2
 NPART(1-5)     .7361   .0304   .0032   .2792   .0106
HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY   85?
   1
WHICH FRUIT ON MAIN  BRANCH WILL BE ABSCISED ON DAY   85?
   9    2    4
HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY   85 ?
   0
DO YOU WANT PLANT  PRINTED OUT ON DAY   85?
   0
IS THERE ANY MORE DATA AFTER DAY   85?
   1
              X   X
              I   I
              X   X   X
              I   I   I
              *   X   0   X   X
              I   I   I   I   I
              *   *   *   X   X   X   X
              I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I
                *   0   X   0   X   X   X
                I   I   I   I   I
                *   X   X   X   X
                I   I   I
                0   X   X
                I
                X
DAY  85  CH20 STRESS 2  H20 STRESS   .5   SOLAR RAD  561.   PLANT WT  62.74
SQUARES LOST  2  BOLLS LOST  0  LAI 3.82  PHYSIOL. DAYS  70  BLOOMS LOST  0
LEAF WT 31.44  MAINSTEM NODES 20 # SQUARES  33 # GREEN BOLLS  8 # SITES  52


      0
      I
      0   X   0
      I   I   I
      *   0   X   X   X   X
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        *   X   0   X   X   X
        I   I
        0   0
        I
        X
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM

THIS IS DAY   85      WHAT IS THE NEXT OUTPUT DAY?
  90
 CONCENTRATIONS   .0213  .0659  .0062  .0062  .0078  NSTRES= 2
 NPART(1-5)     .7076   .0659   .0068   .2777   .0104
HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY   90?
   1
WHICH FRUIT ON MAIN  BRANCH WILL BE ABSCISED ON DAY   90?
   8    2    4
HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY   90 ?
   0
DO YOU WANT PLANT  PRINTED OUT ON DAY   90?
   0
IS THERE ANY MORE DATA AFTER DAY   90?
   1
              X   X
              I   I
              *   0   X
              I   I   I
              *   *   0   0   X
              I   I   I   I   I
              *   0   *   *   0   X   X
```

OUTPUT DATA—Continued

```
              I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I
                *   0   0   0   0   X   X
                I   I   I   I   I
                *   *   0   X   X
                I   I   I
                0   X   X
                I
                X
DAY  90  CH20 STRESS 2  H20 STRESS   .0   SOLAR RAD  492.  PLANT WT  67.95
SQUARES LOST  0  BOLLS LOST  0  LAI 4.04  PHYSIOL. DAYS  75  BLOOMS LOST  0
LEAF WT 33.25  MAINSTEM NODES 20 # SQUARES  19 # GREEN BOLLS 12 # SITES  52


      0
      I
      0   X   0
      I   I   I
      *   0   *   0   X   X
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        *   0   0   0   X   X
        I   I
        0   0
        I
        X
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM


THIS IS DAY   90      WHAT IS THE NEXT OUTPUT DAY?
  95
 CONCENTRATIONS    .0196  .0896  .0049  .0056  .0076  NSTRES= 4
 NPART(1-5)     .6BB3   .0896   .0091   .2779   .0104
HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY   95?
   1
WHICH FRUIT ON MAIN. BRANCH WILL BE ABSCISED ON DAY   95?
   7    2    4
HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY   95 ?
   0
DO YOU WANT PLANT  PRINTED OUT ON DAY   95?
   0
IS THERE ANY MORE DATA AFTER DAY   95?
   1
              0   X
              I   I
              *   0   0
              I   I   I
              *   *   0   0   0
              I   I   I   I   I
              *   0   *   *   0   0   0
              I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I
                0   0   0   0   0   0   X
                I   I   I   I   I
                *   *   0   0   0
                I   I   I
                0   0   0
                I
                0
DAY  95  CH20 STRESS 1  H20 STRESS  2.0   SOLAR RAD  635.  PLANT WT  72.22
SQUARES LOST  0  BOLLS LOST  0  LAI 4.28  PHYSIOL. DAYS  80  BLOOMS LOST  0
LEAF WT 35.20  MAINSTEM NODES 20 # SQUARES   4 # GREEN BOLLS 11 # SITES  52


      0
      I
      0   0   0
      I   I   I
      *   0   *   0   0   0
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        *   0   0   0   0   X
        I   I
        0   0
        I
        X
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM
```

OUTPUT DATA—Continued

```
THIS IS DAY   95     WHAT IS THE NEXT OUTPUT DAY?
 165
 CONCENTRATIONS    .0205  .0955  .0015  .0014  .0051  NSTRES= 1
 HPART(1-5)     .7840   .0955   .0090   .1780   .0099
HOW MANY FRUIT ON MAIN BRANCH WILL BE ABSCISED ON DAY  165?
   0
HOW MANY FRUIT ON VEG. BRANCH WILL BE ABSCISED ON DAY  165 ?
   0
DO YOU WANT PLANT  PRINTED OUT ON DAY  165?
   0
IS THERE ANY MORE DATA AFTER DAY  165?
   0
              X
              I
              O   O   X
              I   I   I
              O   O   O   X   X
              I   I   I   I   I
              #   O   O   O   O   X       X
              I   I   I   I   I   I       I
              O   O   #   O   O   O   O   X   X   X
              I   I   I   I   I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0=
                I   I   I   I   I   I   I   I   I
                O   O   O   O   O   O   O   X   X
                I   I   I   I   I   I
                #   O   O   O   O   X
                I   I   I   I
                O   O   O   X
                I   I
                O   X

DAY 165  CH2O STRESS 0  H2O STRESS   .0   SOLAR RAD  402.  PLANT WT  88.47
SQUARES LOST  0  BOLLS LOST  0  LAI 4.66  PHYSIOL. DAYS 139  BLOOMS LOST  0
LEAF WT 38.29  MAINSTEM NODES 25 # SQUARES  14 # GREEN BOLLS  0 # SITES  66

      O
      I
      O   O   O
      I   I   I
      #   O   O   O   O   O
      I   I   I   I   I   I
==0=0=0=0=0=0=0=0=0=0=0=0=0=0=
        I   I   I   I   I   I
        #   O   O   O   O   O
        I   I
        O   O
        I
        O
VEGETATIVE BRANCH GROWING FROM NODE  6  OF THE MAIN STEM


 YIELD/ACRE 1.272  EMERGENCE DATE 125.  GROWINGDAYS 172  LATITUDE  34.0
# OF GREEN BOLLS  0  # OF OPEN BOLLS  5  SOIL H2O CAPACITY 1.69
H2O RUN OFF  .48  ROW SPACING  101.6  # OF PLANTS/ACRE  41000.
```

LITERATURE CITED

(1) Baker, D. N., Bruce, R. R., and McKinion J. M. 1973. An analysis of the relation between photosynthetic efficiency and yield in cotton. Proc. Beltwide Cotton Prod. Res. Confs. 1973: 110–114.

(2) ———, and Hesketh, J. D. 1969. Respiration and the carbon balance in cotton (*Gossypium hirsutum* L.). Proc. Beltwide Cotton Prod. Res. Confs. 1969: 60–64.

(3) ———, and Myhre, D. L. 1968. Leaf shape and photosynthetic potential in cotton. Proc. Beltwide Cotton Prod. Res. Confs. 1968: 102–109.

(4) Bruce, R. R., and Römkens, M. J. M. 1965. Fruiting and growth characteristics of cotton in relation to soil moisture tension. Agron. J. 57: 135–140.

(5) Duncan, W. G. 1971. SIMCOT: A simulator of cotton growth and yield. Proc. of Workshop on Tree Growth Dynamics and Modeling, Duke University, Oct 11–12, 1971, pp. 115–118.

(6) Jenkins, J. N., Baker, D. N., McKinion, J. M., and Parrott, W. L. 1973. Systems analysis and the evaluation of morphogenetic characters in cotton. *In* Proc. Symp. on The Application of Systems Methods to Crop Production, Mississippi State University, June 7–8, 1973. In press.

(7) Stapleton, H. N. 1970. Crop production in system simulation. Trans. ASAE (Am. Soc. Agric. Eng.) 13: 110–113.

(8) ———, Buxton, D. R., Watson, F. L., Nolting, D. J., and Baker, D. N. 1973. COTTON: A computer simulation of cotton growth. Ariz. Agric. Exp. Stn. Tech. Bull. 206, 124 pp.

(9) ———, and Meyers, R. P. 1971. Modeling subsystems for COTTON: The cotton plant simulation. Trans. ASAE (Am. Soc. Agric. Eng.) 14: 950–953.

PART 5.—HARVSIM: A SIMULATION OF COTTON HARVESTING AND GINNING

By James W. Jones,[1] Rex F. Colwick,[2] D. F. Wanjura,[3] and Elmer B. Hudspeth[4]

DESCRIPTION

HARVSIM simulates harvesting, transporting, storing, and ginning of cotton from a farm in a gin community. See figure 5–1. The focus is on a particular farm where field sizes, cotton maturity rates for each field, and yield of each field are descriptions of the crop. The harvesting and hauling system is specified by the number, capacity, and speed of harvesters and the number and capacity of trailers available to the farmer. The rest of the cotton input to the gin from other farms is simulated by random lumped harvesting rates derived from past gin records. The ginning rate is specified, and an option exists for altering the gin schedule. Breakdowns of harvesters and the gin are simulated, and idle harvester time due to trailer shortages is considered. A trailer hauler takes one or two trailers to and from the gin.

The operator specifies the date when harvesting is to start by selecting the percentage of the crop open when harvesting is to start. Rainfall is an input to the model, and depending on the amount of rainfall, harvesting is stopped for 0, 1, 2, 3, or 4 days with certain probabilities. Daily trailer arrivals from the entire gin community are calculated and include arrivals from the farm under study. The system status is updated every 0.1 hour. Harvesting is simulated for each harvester, each harvester having been assigned to a field, and a trailer is assigned to each harvester for filling. Harvester breakdown and repair times are simulated. Harvesting continues until all fields are harvested once unless a trailer shortage prevents the harvester from unloading. Farm management determines whether to harvest each field twice and specifies a value (in bales per acre remaining in the field) below which the field will not be harvested a second time.

A hauler transports one or two full trailers to the gin and returns trailers to the farm. When trailers from the farm arrive at the gin, they are placed in a first-come, first-served queue. A daily operating schedule for the gin is selected, based on gin backlog. Breakdowns and repair times for gin equipment are simulated. An economic analysis calculates costs for harvesting, transporting, and ginning.

HARVSIM was validated with 1-year data from the Texas High Plains. The simulated and observed harvesting rates and trailer requirements compared well for the two farms that were monitored.

LIMITATIONS

HARVSIM was intended for comparing current methods of handling seed cotton with alternate methods that include seed-cotton storage prior to ginning. The model depicts the current trailer method and focuses on an individual farm, but with estimates of harvested cotton from the rest of the gin community. A second model was developed (HARSTOR) to simulate storage of seed cotton on all farms in a gin community and will be reported later.

HARVSIM is limited to studying individual farm harvesting decisions and the effects of these decisions on costs, harvester idle time, labor requirements, etc. Farm decisions throughout a gin community can also be studied, but the lumped gin input will have to be altered to reflect that change. For example, one could study the effect of a constant number of trailers owned by the gin and used on a first-come, first-served basis by changing the community harvesting rates to reflect that process.

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[4] Location leader, Southern Region, Agricultural Research Service, U.S. Department of Agriculture, Lubbock, Tex. 79401.

The economic analysis for the gin is based totally on High Plains gin data developed at Texas Technological University, Lubbock.[5] A more detailed economic analysis of gin costs is needed to make the model general. The harvesting-hauling economic analysis is based on American Society of Agricultural Engineers cost figures.

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[5] Sandle, W. D., Smith, M. L., and Fowler, Mark. 1970. An industrial engineering study of the operations through which cotton passes between the farm and the mill. Final report on a Cotton Production Institute Project 68-114. 284 pp. Texas Technological University, Lubbock.

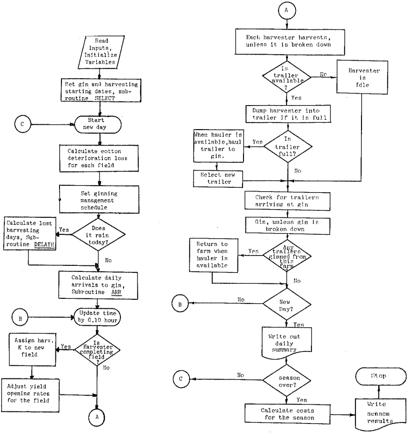
Read Inputs, Initialize Variables
Set gin and harvesting starting dates, subroutine SELECT
C
Start new day
Calculate cotton deterioration loss for each field
Set ginning management schedule
Does it rain today?
Yes
Calculate lost harvesting days, Subroutine DELAYH
No
Calculate daily arrivals to gin, Subroutine ARR
B
Update time by 0.10 hour
Is Harvester completing field ?
Yes
Assign harv. K to new field
No
Adjust yield opening rates for the field
A
A
Each harvester harvests, unless it is broken down
Is trailer available ?
No
Harvester is Idle
Yes
Dump harvester into trailer if it is full
Is trailer full?
Yes
When hauler is available, haul trailer to gin.
Select new trailer
No
Check for trailers arriving at gin
Gin, unless gin is broken down
Any trailers ginned from this farm ?
Yes
Return to farm when hauler is available
No
New Day?
No
B
Yes
Write out daily summary
season over?
No
C
Yes
Calculate costs for the season
Write season results
Stop

FIGURE 5–1.—Simplified flow chart for HARVSIM.

DEFINITION OF TERMS

ACDELT	Acres harvested in one time increment.
ACS(K)	Number of acres in field K (K=1–50).
ACST	Total acres on farm.
AIDT	Amount harvested in one time increment.
AR	Bales arriving at gin today from rest of gin community.
ARPH	Arrival rate in bales per hour.
BGND	Total bales ginned.
BH	Probability of harvester breaking down within a time increment.
BKLG	Bales in gin yard not yet ginned.
BLLS	Total bales harvested from this farm.
CCOT	Cost per pound of lint.
CDEP	Depreciation cost, harvester.
CFLBR	Cost of farm labor for year.
CGIN	Total gin cost per year.
CGLBR	Cost of gin labor for unloading system.
CHARN	Total harvesting cost per year.
CHAUL	Total yearly cost for hauling.
CHL	Cost per mile to operate pickup hauler.
CINS	Insurance cost, harvester.
CINT	Interest cost, harvester.
CLBR	Cost per hour for labor.
CLOSF	Percentage of cotton loss 30 days after boll opening.
CLUB	Lubrication cost per year, harvester.
COTT(K)	Amount of cotton remaining in field K.
COTTT	Total seed cotton on farm.
CTAX	Cost of taxes per year (harvester).
CTLS	Cost per trailer per year.
CTR	Total trailer cost, all trailers.
DGIN	Daily gin volume.
DLAY	Number of days harvesting delayed due to rain.
EFF	Efficiency of harvester.
ENQ	Time when hauler is to arrive at gin.
ENT(JK)	Time trailer JK arrives at gin.
FLDFLG(K)	Harvest status for field K (0=not yet harvested; 1=harvested once; 2=harvested twice).
FOX	Percentage of gin volume arriving today, excluding farm in question.
GAMT	Amount ginned during one time increment.
GCPB	Ginning cost per bale, from study cited in footnote 5.
GDT	Repair time for gin.
GINAR	Midseason daily average gin arrival rate if user wants to specify this.
GOP	Time gin starts running after breakdown.
GRTE	Ginning capacity in bales per hour.
GTO	Gin turnout in percent.
HAMT(J)	Pounds of seed cotton in harvester J.
HARC	Purchase price for harvester.
HARTOL	Tolerance for simulating when the harvester dumps the cotton.
HPH	Hours of harvester operation.
IARFLG	Flag for reading in gin arrival rate parameters or simulating (1=read in, 0=simulate).
ICNT	Counts empty trailers in gin yard belonging to this farm.
IDAL	Days from first open cotton.
IDAY	Day number.
IDL(J)	Total idle time due to trailer shortages for harvester J.
IDT	Time counter during day; each increment is 10 minutes.
IFIELD(K)	Harvester number assigned to field K for harvesting.
IFK	Field DO loop counter.
IFLAG(K)	Trailer status flag: 0=waiting to be filled, 1=being loaded, 2 = trailer full, 3=in transit to gin, 4=in gin queue, 5=empty at gin, and 6=trailer on way home.
IGFLG	Gin operating flag.
IGSTRT	Flag for reading (IGSTRT=0) or calculating gin and harvest starting dates (IGSTRT=1).
IGT	Number of time increments the gin operates today, at 10 minutes each.
IHARV(J)	Field number assigned to harvester J for harvesting (a pointer).
IHEND	Time of day to stop harvest.
IHLR	Trailer hauler status: 0=on farm, 1=on way to gin, 2=at the gin, 3=on way to farm.
IHSTRT	Time of day for starting harvest (0=6:00 a.m., 10=7:00, etc; daily time increment=0.1 hour).
ILAST	Number of days required for season to "tail off" after arrivals start slowing down at end of season.
IMID	Average number of days for arrivals occurring at the midseason rate, total gin community.
INOTIM	Number of current harvest, 1 or 2.
IQN(JL)	Time that trailer JL is ginned.
IQUIT	Number of harvesters completed harvesting for the year.
IRAIN	Flag for reading rain (IRAIN=1) or simulating it (IRAIN=0). (It must be equal to 1 in this program.)
IRDA	Julian days of rainfall input.
IRTRN	Time that hauler returns to farm.
ISH(JFK)	Time when harvester starts harvesting after a breakdown (current time plus repair time).
ISTART	Day when harvest is resumed after a rain.
ISTRT	Number of days required for gin arrival rate to reach midseason average.
ITACS	Total acres harvested to date.
JFK	Harvester counter.
JFLAG(J)	Harvester status flag: 0=harvester can dump load into harvester and 1=idle harvester.
KTT,IZ	Number of trailers hauler pulls to gin this time, 1 or 2.
LBH	Pounds of seed cotton per bale.
LIFE	Years for depreciating harvester.

MASTRT	First day of open cotton.
MATRTE (K,I)	Percent of cotton open on day I (I=1–50 days after MASTRT for field K (K=1–50).
NA	Number of days gin arrivals is increasing in trend (=ISTRT if read in).
NB	Number of days before gin receipts show decline at end of season (=IMID if read in).
NC	End of gin season (=ILAST if read in).
NDAY	Number of days charged for ginning.
NFLD	Number of fields on the farm, ranked in order of earliness.
NGLBR	Number of gin laborers used for unloading system.
NHAUL	Number of trips (total) made to gin.
NHVS	Number of harvesters on the farm.
NOFTIM	Number of harvests per field, 1 or 2.
NRAIN	Number of days of rainfall to read.
NSGN (K)	Harvester number assigned to trailer K.
NTH	Total number of days harvesting, including rain days.
NTLS	Number of trailers on the farm.
NYR	Number of years to be simulated.
PSTART	Percentage of bolls open for starting harvest.
QO	Theoretical acres per hour.
R	Rainfall on day in question.
RFIN (IRDA)	Rainfall amounts on day IRDA.
RL (K)	Row length in field K (K=1–50).
RO	Probability of gin breakdown during one time increment.
RT (I)	Time trailer I is scheduled to return to farm.
SAVCOT	Temporary variable to store amount of cotton remaining in each field.
SGRT	Variation about ginning rate.
SMALY	Lowest yield such that if a field has less than SMALY bales per acre in it, then it will not be harvested.
SV	Salvage value of harvester.
SYA	Standard deviation of YAK.
TACRE	Actual time required per acre.
TACS (K)	Total acres in field K harvested during current harvest.
TAMI (K)	Amount of seed cotton in trailer K.
TCAP	Trailer capacity.
TCN	Total cotton harvested to date.
TCPB	Total cost per bale harvested on farm.
TENQ	Total time elapsed when hauler arrives at gin.
TIDT	Total time increments.
TNBLS	Total arrivals at gin in bales.
TQO	Theoretical time per acre.
TRD	Time to drive to or from gin.
TTRIP	Time required for a harvester round trip in field.
VEL	Average harvesting velocity in miles per hour.
VOL	Gin community volume in bales.
XMI	Miles to the gin.
XO	Amount held by each harvester in pounds.
X, RNX	Random numbers.
YA (K)	Yield per acre in field K (K=1–50).
YAK	(Dummy) yield that has opened.
YLO	Loss of cotton from a field.
YLOS	Total lost cotton, accumulated.

INPUT/OUTPUT

Input

Card 1: Col. 1–5 NYR (Integer)
6–10 NHVS (Integer)
11–15 NTLS (Integer)
16–20 NFLD (Integer)
21–25 NOFTIM (Integer)
26–35 XMI (F10.2)
36–45 GTO (F10.2)
46–55 CLBR (F10.2)
56–65 GRTE (F10.2)
66–75 SMALY (F10.2)

If NFLD is 6:

Cards 2 through 7; 1 card for each field.
Col. 1–10 ACS (K) (F10.2)
11–20 YA (K) (F10.2)
21–30 RL (K) (F10.2)

Card 8: Col. 1–5 MASTRT (Integer)
6–15 PSTART (F10.2)

Card 9 through 24: MATRE (K,I) arranged in F4.2 format starting with field 1; 50 values are read in for maturity values for each field K.

Card 25: Col. 1–10 CTLS (F10.2)
11–20 CHL (F10.2)
21–30 VOL (F10.2)
31–40 HARC (F10.2)
41–50 SV (F10.2)
51–55 LIFE (Integer)

Card 26: Col. 1–10 TCAP (F10.2)
11–20 CCOT (F10.2)
21–30 VEL (F10.2)
31–40 GINAR (F10.2)
41–45 ISTRT (F5.0)
51–55 ILAST (F5.0)
56–60 IARFLG (Integer)

Card 27: Col. 1–5 IRAIN (Integer)
6–10 NRAIN (Integer)

Card 28: As many cards as needed, only if rain is read in.
Col. 1–5 IRDA (day of rain, Integer)
6–10 RFIN (IRDA) (F5.2)
Repeat as needed on same card

and on following cards if needed.

Card 29:	Col. 1–10	CLOSF	(F10.3)
	11–15	IHSTRT	(Integer)
	16–20	IHEND	(Integer)
	21–30	HARCAP	(F10.3)
Card 30:	Col. 1–5	IGSTRT	(Integer)
	6–10	NSG	(Integer)
	11–15	NGLBR	(Integer)

Output

1. Number of harvesters, trailers, and distance to the gin are printed out.
2. For each field, the number of acres, yield, and row length are printed.
3. The total cotton to harvest, gin starting date, and harvesting starting date.
4. Daily gin summary including the number of arrivals, bales ginned, backlog, and hours of operation.
5. Breakdowns are printed when they occur (gin and harvester).
6. Every time a harvester or trailer changes status, the change is printed out, for example, when a harvester is filled and dumped into a trailer, when a trailer returns to the farm, and when a trailer is ginned are outputs.
7. A daily summary is printed for harvesting and ginning.
8. At the end of the season, the trailer utilization is printed for each trailer. The number of bales harvested, hours of harvester operation, and costs per bale are printed out.

PROGRAM SETUP AND EXECUTION

HARVSIM is programed in FORTRAN for a UNIVAC 1106 or IBM 370 computer. The card reader input unit is 1 and the line printer output unit is 3.

The card deck is arranged in the following sequence for a UNIVAC run:

A. Control cards
   1. @RUN
   2. @ASG
   3. @FOR

B. Main program deck

C. @FOR card (in front of each subroutine)

— Subroutine (s) —

D. @MAP card

IN card

E. @XQT card

—data—

F. @FIN card

The @RUN card specifies account number, name of run, and the project qualifier. The @ASG card assigns space on disk for storing the program for future use. The @FOR cards cause the main program and subroutines to be compiled with the FORTRAN compiler. The @MAP card creates an absolute element in machine language with all subroutines linked together for the run and for future runs if desirable. The @XQT card causes program execution, and @FIN signals the end of the program.

PROGRAM LISTING

```
C     HARVESTING-HANDLING SIMULATION
      REAL IDL(4),HAMT(4),ENT(30),TAMT(30),RT(30),TE(30),TT(30),RFIN(400
     1),ISTRT,IMID,ILAST
      DIMENSION    X(1)
      INTEGER TIDT
      INTEGER FLDFLG(50),IFIELD(50),IHARV(4)
      INTEGER IFLAG(30),ION(30),ISH(4),NSGN(30),JFLAG(4)
      DIMENSION ACS(50),YA(50),RL(50),COTT(50),TACS(50)
      REAL*4 MATRTE(50,50)
      DATA IDL/4*0./,HAMT/4*0./,ENT/30*0./,TAMT/30*0./,RT/30*0./,TE/30*0
     1./,TT/30*0./
      DATA TIDT/0/,JFLAG/4*0/,IFLAG/30*0/,ION/30*0/,RFIN/400*0.0/,
     1ISH   /4*0/,NSGN    /30*0/,FLDFLG/50*0/
      DATA IHARV/4*0/,IFIELD/50*0/,TACS/50*0.0/,COTT/50*0.0/
C     1971 RAINFALL DATA FOR LUBBOCK, TEXAS
      NSHIFT=2
C     THE FOLLOWING STATEMENTS INITIALIZE VARIABLES
      NN=1
      DATA NHAUL/0/,IHLR/0/,IRTRN/0/
      DATA IBD/0/,BGND/0./,TNBLS/0./,BKLG/0./,GOP/0./,ISTART/0/
C     READ IN VARIABLES FOR THIS SIMULATION
C     NYR=NUMBER OF YEARS TO BE SIMULATED
C     NTLS=NUMBER OF TRAILERS HE OWNS
C     NHVS=NUMBER OF HARVESTERS FARMER OWNS
C         ACS(K) - NO. ACRES IN FIELD K.
C         YA(K) - AVERAGE YIELD PER ACRE IN FIELD K
C               (ADJUSTED WHEN HARVEST OCCURS)
C         RL(K) - ROW LENGTH IN FIELD K.
C         COTT(K) - AMOUNT OF COTTON REMAINING EACH FIELD
C     XMI=AVERAGE DIST. TO GIN
C     GTO=GIN TURNOUT
C     CLBR=LABOR COST PER HOUR
C     GRTE=GIN CAPACITY PER HOUR, RATED
C     CLOT=COST PER LB. OF LINT LOST
C         NOFTIM - NO. OF TIMES TO HARVEST, 1 OR 2.
C         INOTIM - CURRENT HARVEST, 1 = FIRST, 2 = SECOND TIME
C         NFLD - NO. OF FIELDS ON THE FARM.
C         MASTRT - STARTING DAY NO. FOR READ IN MATURITY CURVES.
C         MATRTE(I,K) - MATURITY RATE, PERCENT OF FINAL YIELD  OPEN
C               ON DAY K, FOR FIELD I.
C         SMALY - SMALLEST YIELD THAT WE WILL HARVEST, >=0.0
C         IRAIN - FLAG FOR READING IN RAIN OR SIMULATING IT.
C               0 = SIMULATED    1 = READ IN
C         NRAIN - NO. OF RAINFALL DAYS TO READ IN.
C         IHARV(J) - FIELD NO. ASSIGNED TO HARVESTER J.
C         FLDFLG(K) - HARVEST STATUS FOR FIELD
C               0 = NOT YET HARVESTED   1 = HARVESTED 1 TIME
C               2 = HARVESTED 2 TIMES
C         TACS(K) - TOTAL ACRES COMPLETED HARVESTING, FIELD K,
C               FOR THIS PARTICULAR HARVEST.
C         IQUIT - NO. OF HARVESTERS RETIRED FOR THE SEASON
C
C
C
      READ(1,1) NYR,NHVS,NTLS,NFLD,NOFTIM,XMI,GTO,CLBR,GRTE,SMALY
    1 FORMAT(5I5,5F10.2)
      READ(1,1111)(ACS(K),YA(K),RL(K),K=1,NFLD)
 1111 FORMAT(3F10.2)
      READ(1,1140) MASTRT,PSTART
 1140 FORMAT(I5,F10.2)
      NN=1
      X(1)=0.62412
      READ(1,1112)((MATRTE(I,K),K=1,50),I=1,NFLD)
 1112 FORMAT(20F4.2)
      READ(1,501) CTLS,CHL,VOL,HARC,SV,LIFE
      READ(1,927) TCAP,CCOT,VFL,GINAR,ISTRT,IMID,ILAST,IABFLG
      READ(1,760) IRAIN,NRAIN
  760 FORMAT(2I5)
      IF(IRAIN.EQ.1) READ(1,761)(IRDA,RFIN(IRDA),I=1,NRAIN)
  761 FORMAT(8(I5,F5.2))
      IQUIT=0
  501 FORMAT(5F10.2,I5,F10.2)
  927 FORMAT(4F10.2,3F5.0,I5)
```

PROGRAM LISTING—Continued

```
      INOTIM=1
      IX=78347
      TCAP=(TCAP*479./GTO)*100.
C     FOLLOWING STMT. ACCOUNTS FOR EXTRACTOR COTTON
      GRTE=GRTE+GRTE*(5.8333*(GTO-21.3)/100.)
C
C
      YLO=0.0
      YLOS=0.
      WRITE(3,610)
  610 FORMAT('1',10X,'HARVEST-GIN  FOR N.C. STATE EXAMPLE')
      WRITE(3,614)
  614 FORMAT('0',4X,'                    NO.HARV.  NO.TRAILERS   TRAILER CAP.
     1  DIST.TO GIN')
      WRITE(3,611)          NHVS,NTLS,TCAP,XMI
  611 FORMAT('0',21X,I3,8X,I3,9X,F7.1,8X,F5.1,/)
      WRITE(3,1109)
 1109 FORMAT('0',2X,'FIELD',15X,'ACRES',15X,'YIELD',10X,'ROW LENGTH')
      WRITE(3,1113)(IFK,ACS(IFK),YA(IFK),RL(IFK),IFK=1,NFLD)
 1113 FORMAT(' ',I5,7X,F15.2,5X,F15.2,3X,F15.2)
C     START A NEW YEAR
      IYR=0
      READ(1,759) CLOSF,IHSTRT,IHEND,HARCAP
  759 FORMAT(F10.3,2I5,F10.3)
C         CLOSF = COTTON LOSS FACTOR
C         IHSTRT = BEGIN HARVEST (0 IS 6:00 A.M.)
C         IHEND = STOP HARVEST.
 1000 IYR=IYR+1
C     TCN IS TOTAL COTTON HARV THIS YEAR
C     TIACS IS TOTAL ACRES HARV THIS YEAR
      TCN=0.
C     SELECT COMPUTES THE GIN STARTING DATE, AND THE HARVEST STARTING DAY
      READ(1,751) IGSTRT,NSG,NSH,NGLBR
  751 FORMAT(4I5)
      ACST=0
      COTTT=0
      TIACS=0
      DO 1114 IFK=1,NFLD
      COTT(IFK)=(ACS(IFK)*YA(IFK)*100.0/GTO)*479.0
      ACST=ACST+ACS(IFK)
 1114 COTTT=COTTT+COTT(IFK)
      IF(IGSTRT.EQ.1) GO TO 750
      CALL SELECT(NSG,NSH,X,IX,PSTART,MASTRT,MATRTE)
750   WRITE(3,60)NSG,NSH,COTTT
   60 FORMAT(' ','GIN STARTING DAY IS',I4,//,'HHARV. STARTING DAY IS',
     1I4,//,'TTOTAL COTTON TO HARVEST IS',F10.1,'POUNDS',//)
C
C
C
C         ASSIGNS HARVESTERS TO FIELDS INITIALLY
C         IFIELD(K) - HARVESTER NO. ASSIGNED TO FIELD K.
      DO 1117 J=1,NHVS
      IFIELD(J)=J
 1117 IHARV(J)=J
C
C     IDAY=DAY NO.
      DO 999 IDAY=NSG,388
      IDAL=IDAY-MASTRT+1
      IF(IDAL.GT.50) IDAL=50
C
C         IDAL - NO. OF DAYS SINCE SEED COTTON STARTED
C           OPENING, MAX. OF 50.
C
C         COTTON DETERIORATION FACTOR, CLOSF
C
      IF(IDAY.LT.MASTRT+30) GO TO 1115
      IDAQ=IDAY-(MASTRT+30)+1
      IF(IDAQ.GT.50)IDAQ=50
      DO 1116 IFK=1,NFLD
      SAVCOT=COTT(IFK)
      COTT(IFK)=COTT(IFK)*(1.0-(CLOSF*MATRTE(IFK,IDAQ))*((ACS(IFK)-TACS(
     1IFK))/ACS(IFK)))
      YLO=SAVCOT-COTT(IFK)
      IF(YLO.LT.0.0) YLO=0.0
      YA(IFK)=YA(IFK)*(1.0-CLOSF*MATRTE(IFK,IDAQ))
 1116 YLOS=YLOS+YLO
      WRITE(3,10778) YLOS
10778 FORMAT(' ','YLOS= ',F10.2)
 1115 CONTINUE
```

PROGRAM LISTING—Continued

```
      IDT=0
C
C     DELAYH IS FOR SIMULATING RAIN AND DELAYSIN HARV. DUE TO RAIN
C     ISTART IS STARTING DAY FOR HARVEST AFTER RAINFALL
      CALL DELAYH(X,NN,R,IDAY,ISTART,IRAIN,RFIN)
C
C     THIS SUBROUTINE CALCULATES ARRIVALS FOR THE DAY AND DETERMINES
C     WHETHER GIN IS RUNNING
C     AR=BALES ARRIVED AT GIN TODAY
C     IGFLG=0 MEANS GIN IS OPERATING; IGFLG=1 MEANS RAINED OUT
C    IF ISTART .GT. IDAY,IAR.GT. 0 AND NO. GIN ARRIVALS FOR DAY
      NDAY=IDAY-NSG-(IDAY-NSG)/7
      IAR=ISTART-IDAY
      CALL ARR(R,X,NN,AR,NDAY,IGFLG,VOL,IAR,GINAR,ISTRT,IMID,ILAST,IARFL
     1G)
      IF(IDAY/7*7-IDAY.EQ.0)AR=0
C     IF THERF IS A DELAY IN HARV. DUE TO RAIN, GO TO GINNING
C
C        ****************************************************************
C        FOLLOWING IS GIN MANAGEMENT SCHEDULE BASED ON BACKLOG.
C
      IGT=110
      IF(BKLG.GT.100.AND.NSHIFT.EQ.2)IGT=230
      IF(BKLG.GT.100.) GRTE=16.8
      IF(IDAY.GE.NSG+56) IGT=110
      IF(IDAY.GE.NSG+56) GRTE=16.8
C
C        ****************************************************************
C
      DGIN=0.
C     IDT IS TIME COUNTER DURING DAY
   20 IDT=IDT+1
C     TIDT=TOTAL NO. OF TIME INCREMENTS
      TIDT=TIDT+1
      IF(IDAY.LT.NSH.OR.IDAY.LE.ISTART) GO TO 6
      IF(IDAY/7*7-IDAY.EQ.0) GO TO 6
C        HARVEST BETWEEN IHSTRT AND IHEND, 0=6:00 A.M.
      IF(IDT.LE.IHSTRT.OR.IDT.GT.IHEND) GO TO 6
C
      IF(IQUIT.EQ.NHVS) GO TO 1123
 1124 CONTINUE
C
C        CHECK FOR HARVESTERS COMPLETING A FIELD
C
      DO 1119 JFK=1,NHVS
      IU=IHARV(JFK)
      IF(IHARV(JFK).EQ.0) GO TO 1126
      IF(TACS(IU        ).LT.ACS(IU         )) GO TO 1119
      IFIELD(IU        )=0
      FLDFLG(IU        )=1
      IF(INOTIM.EQ.2) FLDFLG(IU         )=2
      TACS(IU        )=0.0
      WRITE(3,1130) IHARV(JFK),IDAY,FLDFLG(IU         ),COTT(IU
      YA(IU        )=COTT(IU         )/(ACS(IU         ))*GTO/47900.0
      WRITE(3,7111) YA(IU         )
7111  FORMAT(' ','YA  ',F10.5)
      IHARV(JFK)=0
1126  CONTINUE
C
C        SELECT NEW FIELD FOR HARVESTFR JFK
C
      DO 1120 IFK=1,NFLD
      IF(IFIELD(IFK).GT.0) GO TO 1120
      IF(YA(IFK).LT.SMALY) GO TO 1120
      IF(MATRTE(IFK,IDAL).LT.0.99.AND.INOTIM.EQ.2) GO TO 1120
      IF(FLDFLG(IFK).EQ.INOTIM-1) GO TO 1121
1120  CONTINUE
      IF(INOTIM.EQ.2) IHARV(JFK)=0
      IF(INOTIM.EQ.2) GO TO 1119
      IF(NOFTIM.EQ.1) IHARV(JFK)=0
      IF(NOFTIM.EQ.1) GO TO 1119
      TIACS=0.0
      INOTIM=2
      GO TO 1124
 1121 IHARV(JFK)=IFK
      IFIELD(IFK)=JFK
C
C        SELECTED NEW FIELD (IFK) FOR HARVESTER.(JFK)
C
```

PROGRAM LISTING—Continued

```
      IF(IDAL.GE.50) GO TO 1161
      IF(MATRTE(IFK,IDAL).GE.0.9999) GO TO 1161
      DO 1160 IDA1=IDAL,50
      MATRTE(IFK,IDA1)=(MATRTE(IFK,IDA1)-MATRTE(IFK,IDAL))/(1.0-MATRTE(I
     1FK,IDAL))
      WRITE(3,7112) MATRTE(IFK,IDA1),IDA1
7112  FORMAT(' ','MAT  ',F10.5,'  IDA1  ',I10)
1160  CONTINUE
 1161 CONTINUE
C
C        OPENING RATE IS ADJUSTED TO REMAINING COTTON
C        IN THE FIELD, AFTER FIELD IS HARVESTED 1 TIME.
C
C
 1119 CONTINUE
      IQUIT=0
      DO 1122 JFK=1,NHVS
1122  IF(IHARV(JFK).EQ.0) IQUIT=IQUIT+1
      IF(IQUIT.EQ.NFLD) GO TO 1123
      GO TO 4
 1123 CONTINUE
 1130 FORMAT('0',10X,'COMPLETED HARVESTING FIELD NO.',I5,5X,'ON DAY',I5,
     15X,'THIS FIELD HAS BEEN HARVESTER',I2,1X,'TIME',/,' ','REMAINING C
     2OTTON IS ',F10.0)
C
C
C     CHECK IF ALL TRAILERS ARE GINNED IF ALL COTTON IS HARVESTED
      DO 5 I=1,NTLS
      IF(TAMT(I).GT.50.0) GO TO 8018
    5 CONTINUE
      GO TO 7
    4 CONTINUE
C
C
      NOH=IDAY
      DO 632 IC=1,NTLS
      IF(IFLAG(IC).EQ.0.OR.IFLAG(IC).EQ.5.OR.IFLAG(IC).EQ.6)TF(IC)=
     1TF(IC)+0.1
  632 TT(IC)=TT(IC)+0.1
C     HARVESTING CALCULATIONS
C     FOR EACH HARVESTER, HARVEST DURING AT
      DO 8 J=1,NHVS
      IF(IHARV(J).EQ.0) GO TO 8
      IF(TIDT.LT.ISH(J))GO TO 8
C     BREAK DOWN OCCURS EVERY  8 HOURS ON AVERAGE AND REQUIRES 1.2 HOURS
C              FOR REPAIR ON AVERAGE
      BH=1.-EXP(-0.1/8.0)
      X(1)=X(1)*8192.*16384.
      CALL RANDU(X,NN)
      RNX=X(1)
      IF(RNX.GT.BH) GO TO 1061
      SUH=0.
      DO 1062 IR=1,4
      X(1)=X(1)*8192.*16384.
      CALL RANDU(X,NN)
 1062 SUH=SUH+X(1)
      RNX=X(1)
      DTH=12.*ALOG(1.-RNX)
      WRITE(3,1063) J,IDT,IDAY,DTH
 1063 FORMAT(' ','HARVESTER NO.',I4,'BREAKS DOWN, TIME',I4,'OF DAY',I4,
     16X,'REPAIR TIME IS',F6.1,'TIME INCREMENTS')
      ISH(J)=TIDT+ABS(DTH)
 1061 CONTINUE
C     LBH=POUNDS OF SEED COTTON PER BALE
      LBH=(479./GTO)*100
      IU=IHARV(J)
      YAK=YA(IU       )*MATRTE(IU       ,IDAL)
      SYA=YAK/6.0
      CALL  GAUSS(X,NN,SYA,YAK,VYA)
      IF(VYA.GT.1.25)VEL=5.-1.33*(VYA-1.25)
      QO= VEL*6.67     /8.25
C     QO=ACRES PER HOUR,THEORETICAL
C     TWO=THEORETICAL TIME PER ACRE
C     IF ALL COTTON HAS BEEN HARV, CHECK ON TRAILER STATUS
C     XO=AMT HELD BY EA. HARV, LBS.
      TWO=1./QO
      A=8910.89/(2.*VEL)
      B=163.4/(2.*RL(IU       )/1200.)
      XO=LBH*HARCAP
```

PROGRAM LISTING—Continued

```
      C=90.*LBH*VYA/XO
      IF(IDT.EQ.60) WRITE(3,1010) A,B,C,EFF
 1010 FORMAT(' ',3F8.1,6X,F8.3,6X,'A,B,C,EFF')
      DT=600.0*(YA(IU        )*MATRTE(IU        ,IDAL)/TCAP)
      EFF=A/((6./5.)*(A+B+C+DT))
      TACRE=T00/EFF
C     ACDELT IS ACRES HARV IN DELTA T
      ACDELT=(1./TACRE)*0.1
      RTRIP=(RL(IU        )/6534.)*2.
C     TRAILERS AND A HAULER ARE READY, HAUL TO GIN.
      TTRIP=TACRE*RTRIP
C     IF AT THE START OF THIS TIME PERIOD, A HARV. IS FULL, IT IS ASSUME
C                 TO BE IDLE
      PI1=479.0/(GTO*13000.0)
      HARTOL=PI1*YA(IU        )*RL(IU        )*2.0*MATRTE(IU        ,IDAL)
      IF(HARTOL.GT.500) HARTOL=500.
      IF(HAMT(J).GT.XO-HARTOL) GO TO 10
C     AIDT=AMT. IN HARVESTER DURING DELTA-T
      AIDT=(1./TACRE)*0.1*VYA*LBH
C     HAMT(J)=AMT. IN JTH HARV.
      HAMT(J)=HAMT(J)+AIDT
      TACS(IU        )=TACS(IU        )+ACDELT
      TTACS=TTACS+ACDELT
      COTT(IU        )=COTT(IU        )-AIDT
      IF(COTT(IU        ).LT.0.0) COTT(IU        )=0.0
      TCN=TCN+AIDT
C         IF THE HARV. BASKET IS WITHIN HARTOL LBS
C         OF CAPACITY, THEN IT IS
C          DUMPED, OTHERWISE, LOOK FOR NEXT HARV.
      IF(HAMT(J).LE.XO-HARTOL) GO TO 8
C
   10 CONTINUE
C     LOOK AT TRAILERS TO SEE IF WE CAN DUMP HQRV.
C     CHECKS FOR EMPTY TRAILERS; IF ONE IS EMPTY, THE FLAG IS SET FOR
C                FILLING IT
      DO 11 K=1,NTLS
      IF(IFLAG(K).EQ.1.AND.NSGN(K).EQ.J) GO TO 12
   11 CONTINUE
      DO 37 K=1,NTLS
      IF(IFLAG(K).EQ.0) NSGN(K)=J
      IF(IFLAG(K).EQ.0) IFLAG(K)=1
      IF(IFLAG(K).EQ.1.AND.NSGN(K).EQ.J) WRITE(3,601)K,IDT,IDAY,J
  601 FORMAT(' ','TRAILER NO.',I3,2X,'IS SELECTED TO BE FILLED AT TIME',
     1I4,2X,'OF DAY',I4,2X,'BY HARVESTER',I2)
      IF(IFLAG(K).EQ.1.AND.NSGN(K).EQ.J) GO TO 12
   37 CONTINUE
C     NSGN(K)=ASSIGNING THE KTH TRAILER TO THE JTH HARV.
C     IFLAG=0 MEANS TRAILER WAITING TO BE FILLED
C     IFLAG=1 MEANS TRAILER IS BEING LOADED
C     IFLAG=2 MEANS TRAILER IS FULL
C     IFLAG=3 MEANS TRAILER IS IN TRANSIT TO GIN
C     IFLAG=4 MEANS TRAILER IS IN QUEUE
C     IFLAG=5 MEANS TRAILER EMPTY AND ON GIN YARD
C     IFLAG=6 MEANS TRAILER ON WAY HOME
C     IF DO LOOP COMPLETED, NO TRAILER AVAIL.
C     JFLAG(J)=0 LETS HARV DUMP
C     JFLAG(J)=1 MEANS IDLE HARV.
      JFLAG(J)=1
      IDL(J)=IDL(J)+0.1
      GO TO 8
C
C     FILLING THE K+H TRAILER FROM THE J+H HARVESTER
   12 TAMT(K)=TAMT(K)+HAMT(J)
      IF(TAMT(K).GT.TCAP-500.)IFLAG(K)=2
      IF(IFLAG(K).EQ.2)WRITE(3,602)K,IDT
  602 FORMAT(' ','TRAILER NO.',I4,2X,'WAS FILLED AT TIME',I4)
C     CHECKS FOR FULL TRAILERS
      WRITE(3,64)IDAY,IDT,J,HAMT(J),K,TAMT(K),IHARV(J),IDL(J)
   64 FORMAT(' ',6X,'DAY',I4,'TIME',I4,6X,'HARVESTER NO.',I2,'HAS',F8.1,
     1'LBS. OF SEED COTTON BEING DUMPED INTO TRAILER',I3 ,/,' WHICH NOW
     1HAS',F10.1,'LBS. OF SEED COTTON',10X,'FIELD NO.',I5,6X,'IDLE TIME=
     1',F4.0)
C     EMPTIES THE J+H HARV.
      HAMT(J)=0.
      JFLAG(J)=0
    8 CONTINUE
C
C
8018  IKD=0
```

PROGRAM LISTING—Continued

```
C       AFTER HARV. DURING DELTA T, THE TRAILERS ARE EXAMINED AND IF TWO
        IF(IHLR.NE.0)GO TO 6
C       TO SEE IF ANY TRAILERS LEFT ON FARM; IF SO HE WILL HAUL 1 TRAILER
        DO 83 IT=1,NTLS
        IF(IQUIT.EQ.NHVS.AND.IFLAG(IT).EQ.2) IFLAG(IT)=3
        IF(IFLAG(IT).EQ.3)GO TO 18
   83   CONTINUE
        TRD =0
        DO 17 IT=1,NTLS
        TRDK=0
        IF(IFLAG(IT).EQ. 2)TRDK=1
   17   TRD=IRD+IRDK
        KTT=0
        DO 112 IT=1,NTLS
        KT=0
        IF(IRD.LT.2)GO TO 6
        IF(IFLAG(IT).EQ.2) KT=1
        KTT=KTT+KT
        IF(KT.EQ.1)IFLAG(IT)=3
        IF(IFLAG(IT).EQ.3) WRITE(3,603) IT,IDT
  603   FORMAT(' ','TRAILER NO.',I4,2X,'LEAVES FOR GIN AT TIME',I4)
        IF(KTT.EQ.1) GO TO 18
  112   CONTINUE
        GO TO 6
C       IHLR IS THE PICK-UP DRIVER
C       IHLR=0 ,HE IS ON FARM
C       IHLR=1, HE IS ON WAY TO GIN
C       IHLR=2, HE IS AT GIN
C       IHLR=3, HE IS ON WAY TO FARM
   18   IHLR=1
        NHAUL=NHAUL+1
        TRD=(XMT/15.)*10.
        ENQ=IDT+TRD+2
        TENQ=TIDT+TRD+2
        DO 23 JK=1,NTLS
        IF(IFLAG(JK).NE.3)GO TO 23
        ENT(JK)=TENQ
   23   CONTINUE
C
C
C       GINNING PORTION OF PROGRAM
    6   CONTINUE
        IZ=0
        ARPH=0.
        IF(IDT.GT.IHSTRT.AND.IDT.LT.IHEND) ARPH=(AR/(IHEND-IHSTRT))*10.
        TNBLS=TNBLS+ARPH/10.
C
C       TNBLS=TOTAL NO. OF BALES ARRIVED AT GIN, ACCUMULATED
C       THIS LOOP CHECKS FOR TRAILERS ARRIVING DURING THIS DELTA-T
        DO 27 JL=1,NTLS
        IF(TIDT.LT.ENT(JL).OR.IFLAG(JL).NE.3) GO TO 27
        IF(IHLR.EQ.1)IHLR=2
        IF(IHLR.NE.2) GO TO 27
        IRT=TIDT+2
C       IRTRN=TIME HAULER GETS BACK TO FARM
        IRTRN=IRT+(XMI/15.)*10.
        IF(IFLAG(JL).EQ.3)GO TO 29
C       IGN=TIME THE I+H TRAILER ENTERS THE GIN QUEUE
        TNBLS=TNBLS+TCAP*(GTO/47900.)
        GO TO 27
   29   IFLAG(JL)=4
        IZ=IZ+1
        IGN(JL)=BKLG-X(1)*ARPH*0.1+BGND+(TCAP*GTO/47900.0)
        IF(IZ.EQ.2)IGN(JL)=BKLG-RNX*ARPH*0.1+2.0*(TCAP*GTO/47900.0)+BGND
        WRITE(3,71)JL,IDT,IDAY,BKLG
   71   FORMAT(' ','TRAILER NO.',I4,2X,'ENTERS GIN QUEUE AT TIME',I4,2X,'
       1OF DAY',I4,', GIN BACKLOG IS',F9.1,2X,'BALES')
   27   CONTINUE
C
        IF(TIDT.EQ.IRTRN.AND.IHLR.EQ.2) IHLR=0
        IF(IGFLG.EQ.1) GO TO 998
        IF(TIDT.LT.GOP) GO TO 998
        IF(BGND.GE.TNBLS-0.7)GO TO 997
C       CALCULATES GIN FAILURE TIMES AND DOWN TIMES, SETS GOP FOR WHEN
C               GIN IS FIXED AND STARTS TO OPERATE AGAIN
        PU=1.-EXP(-0.1/12.)
        X(1)=X(1)*8192.*16384.
        CALL RANDU(X,NN)
        RNX=X(1)
```

PROGRAM LISTING—Continued

```
      IF(RNX.GT.RO) GOTO 30
C     GIN BREAKS DOWN IF RNX LESS THAN PROB. OF FAILURE
      SUX=0.
      DO 1001 IR=1,4
      X(1)=X(1)*8192.*16384.
      CALL RANDU(X,NN)
 1001 SUX=SUX+X(1)
      RNX=X(1)
C     WITH 10 HERE, IT MEANS 1 HR. AVERAGE REPAIR TIME
      GOT=10.*ALOG(1.-RNX)
      GOP=TIDT+ABS(GOT)
      WRITE(3,604)IOT,IDAY,GOT
  604 FORMAT(' ','GIN BREAKS DOWN AT TIME',I4,2X,'OF DAY',I4,2X,'REPAIR
     1TIME IS',F6.1,2X,'TIME INCREMENTS')
C     ONLY WHEN TIDT IS GREATER THAN GOP DOES GIN BEGIN TO OPERATE AGAIN
   30 CONTINUE
C
C     RANDOMLY COMPUTES AMT GINNED DURING AT
      SGRT=0.6
      CALL GAUSS(X,NN,SGRT,GRTE,GAMT)
      GAMT=GAMT*0.1
      IF(BKLG.LT.0.1) GO TO 996
      IF(GAMT.GT.BKLG) GAMT=BKLG
      DGIN=DGIN+GAMT
      BGND=BGND+GAMT
  996 BKLG=TNBLS-BGND
  997 CONTINUE
      IMPT=0
C
C     IMPT=NO. TRAILERS READY TO BE HAULED BACK TO FARM, MAX. OF 2
C     CHECKS FOR TRAILERS BEING GINNED AND RETURNED TO FARM
      DO 282 I=1,NTLS
      IF(IFLAG(I).NE.4)GO TO 282
      IF(IQN(I).GT.BGND)GO TO 282
      IFLAG(I)=5
      TAMT(I)=0.
      WRITE(3,605)I,IDT
  605 FORMAT(' ','TRAILER NO.',I4,2X,'IS GINNED. TIME IS',I4)
  282 IF(IFLAG(1).EQ.5)IMPT=IMPT+1
      ICNT=0
      DO 40 I=1,NTLS
      IF(IFLAG(I).NE.5)GO TO 41
      IF(IHLR.EQ.1.OR.IHLR.EQ.3)GO TO 41
      IF(IHLR.EQ.0.AND.IMPT.EQ.1) GO TO 41
      IF(IDT.GT.80) GO TO 40
      ICNT=ICNT+1
      RT(I)=TIDT+(XMI/15.)*10.
      IF(IHLR.EQ.0)RT(I)=TIOT+((XMI/15.)*10.)*2.
      IF(ICNT.EQ.2.OR.IHLR.EQ.2)IHLR=3
      IF(ICNT.EQ.2)NHAUL=NHAUL+1
      IFLAG(1)=6
   41 IF(TIDT.GT.RT(I).AND.IFLAG(I).EQ.6) GO TO 111
      GO TO 40
  111 IFLAG(I)=0
      WRITE(3,114)I,IDT,IDAY
  114 FORMAT(' ','TRAILER NO.',I4,2X,'RETURNS TO FARM AT TIME',I4,2X,
     1'OF DAY',I4)
      IHLR=0
   40 CONTINUE
  998 CONTINUE
      IF(IDT.LT.IGT)GO TO 20
      IGT=IGT/10
      WRITE(3,606)
  606 FORMAT('0',//,' ',32X,'DAILY GIN SUMMARY')
      WRITE(3,607)
  607 FORMAT('0',1X,'DAY NO. NO.ARRIVALS   BALES GINNED  TOTAL BALES
     1 TOTAL BALES  CURRENT   OPERATING',/,' ', 12X,'BALES',10X,'TODAY',
     17X, 'RECEIVED',7X,'GINNED',5X,'BACKLOG',3X,'HOURS TODAY'//)
      WRITE(3,608)IDAY,AR,DGIN,TNBLS,BGND,BKLG,IOT
  608 FORMAT(' ',I6,F12.1,F13.1,F12.0,8X,F8.0,F11.1,8X,I3,//)
      IF(IDAY.GT.410.AND.BKLG.LT.2) GO TO 7
      IF(TTACS.GE.ACST) GO TO 999
      WRITE(3,733)
  733 FORMAT('0',6X,'DAILY HARVESTING SUMMARY')
      WRITE(3,615)
  615 FORMAT('0',4X,'HOURS',6X,'TOTAL ACRES   TOTAL COTTON   HARVESTER',
     15X,'WHICH HARVEST',
     1/,'   OPERATION    HARVESTED      HARVESTED      IDLE TIME')
      DO 612 IH=1,NHVS
```

PROGRAM LISTING—Continued

```
612 WRITE(3,613) IH,TTACS,TCN,IDL(IH),INOTIM
613 FORMAT('0',2X,I2,2X,'6',7X,F7.2,7X,F9.1,9X,F5.1,11X,I2,/)
999 CONTINUE
  7 CONTINUE
    CTLS = COST PER TRAILER PER YEAR
    CTR= TOTAL COST OF TRAILERS  PER YEAR
    NHAUL = NUMBER OF TRIPS HAULER MAKES TO THE GIN
    CHL = COST PER MILE TO OPERATE PICKUP HAULING,NOT COUNTING LABOR
    CHAUL= TO TAL YEARLY COST FOR HAULING TO GIN
    NTH= TOTAL NO. OF DAYS HARVESTING,INCLUDING RAINY DAYS
    CFLBR=TOTAL COST OF FARM LABOR FOR YEAR
    CGLBR=COST OF GIN LABOR FOR UNLOADING SYSTEM AT GIN
    NGLBR=NO.OF LABORERS FOR THIS GIN UNLOADING SYSTEM
    GCPB=GIN COST PER BALE,FROM SMITH UPDATED STUDY
    VOL=GIN SEASONAL VOLUME
    HPH=HOURS RUN PER HARVESTER
    ASSUME 3 GAL PER HR AT .33 PER GAL.
    CTAX=TAXES/YR.
    CLUB=LUB.COSTS/YEAR
    CINS=INSURANCE COST
    CINT=INTEREST COST
    CDEP=DEPRECIATION COST
    CHARN=TOTAL COST OF HARVESTING FOR YEAR
    CGIN=TOTAL GIN COST FOR YEAR
    TCPB=TOTAL COST PER BALE
    CLOS=YLOS*CCOT*GTO/100.
    CTR=NTLS*CTLS
    CHAUL=NHAUL*CHL*XMI*2.
    NTH=1+NOH-NSH-(NOH-NSH)/7
    CFLBR=(CLBR*8.*NTH)*(NHVS+2+NHVS/3)
    CGLBR=(CLBR*TIOT/10.)*NGLBR
    GCPB=15.98+(24028.65+2547.29*GRTE)/BGND
    HPH=(1.0/(ACOELT*10.0))*ACST/NHVS
    CFUEL=HPH*0.99
    CLUB=0.15*CFUEL
    CTAX=0.01*HARC
    CINS=0.005*HARC
    CINT=((HARC+SV)/2.)*0.07
    CDEP=(HARC-SV)/LIFE
    CREP=0.01*HARC
    CHARV=CFUEL+CLUB+CTAX+CINS+CINT+CDEP+CREP
    CHARV=CHARV*NHVS
    BLLS=TCN*(GTO/100.)/479.
    CGIN=GCPB*BLLS
    TCPB=GCPB+(CHARV+CTR+CHAUL+CFLBP+CLOS)/BLLS
    WRITE (6,635)
    DO 634 IC=1,NTLS
    TI(IC)=TT(IC)-TE(IC)
634 WRITE(3,633) IC,TE(IC),TT(IC)
635 FORMAT('0',10X,'TRAILER UTILIZATION',//,4X,'TRAILER',6X,'EMPTY',
   16X,'FULL')
633 FORMAT(' ',7X,I3,7X,F6.1,5X,F9.1)
    WRITE(3,1080) BLLS,HPH,NTH,CLOS
1080 FORMAT(' ','BALES HARVESTED-',F6.1,//,' ','HOURS OPERATION PER HAR
   1VESTER-',F7.2,//,' ','DAYS LABOR CHARGED FOR HARVESTING',I5,//,' '
   2,'LOST COTTON COST-',F8.2)
    WRITE (6,502) IYR , CHAUL , CFLBR , CHARV , CGIN , TCPB
502       FORMAT ('0', 10X , 'YEAR-NO' , I2 , / ,'HHAULING COST', 8X ,
   1F8.2 ,/, 'FFARM LABOR COST', 5X , F8.2 ,/, 'HHARVESTER COST',5X ,
   1F9.2 ,/,'GGINNING COST', 8X , F8.2 ,/, 1X , 28(1H*) , // ,'TTOTAL
   1COST PER BALE IS', F6.2 ,'FOR HARVESTING , HAULING , AND GINNING',
   1F8.2,2X,'BALES')
    IF(IYR.LT.NYR)GO TO 1000
    STOP
    END



    SUBROUTINE SELECT(N,M,X,NN,PSTART,MASTRT,MATRTE)
    DIMENSION  MATRTE(50,50)
    NSG=GIN STARTING DATE
    NSH=HARVESTING STARTING DATE
    XN=AVG. GIN STARTING DATE
    XM=AVG. FIRST HARV. DATE
    SN AND SM ARE MEASURES OF VARIATION
    XN=287.
    XM=308.
```

PROGRAM LISTING—Continued

```
      SN=3.
      CALL GAUSS(X,NN,SN,XN,G)
      N=G
      DO 1I=1,50
      IF(MATRTE(1,I).LT.PSTART)GO TO 1
      M=MASTRT+I+1
      GO TO 2
    1 CONTINUF
    2 RETURN
      END



      SUBROUTINE DELAYH(X,NN,R,IDAY,ISTART,IRAIN,RFIN)
      DIMENSION RFIN(400),X(1)
C     R=RAINFALL, INCHES
      IF(IRAIN.EQ.1) GO TO 20
      CALL RAIN(R,X,NN)
      GO TO 30
   20 R=RFIN(IDAY)
   30 CONTINUE
      XK1=0.6
      SK1=0.15
      XK2=1.00
      SK2=0.20
      XK3=2.00
      SK3=0.40
C     THE PREC. VARIABLES OESCPIBE A DELAY STEP FUNCTION WHFRF STFP
C     BREAK POINTS ARE RANDOMLY CHOSEN
      IF(R.LT.0.01) GO TO 71
      CALL GAUSS(X,NN,SR1,XR1,DLMT1)
      CALL GAUSS(X,NN,SR2,XR2,DLMT2)
      IF(R.LT.OLMT1)DLAY=3.
      IF(R.GT.DLMT1.ANO.R.LT.DLMT2)DLAY=4.
      IF(R.GT.DLMT2)DLAY=5.
   72 IDLAY=DLAY+0.1
      IF(ISTART.GT.IDAY)ISTART=ISTART+IDLAY
      ISTART=IDAY+IDLAY
      IF(ISTART-IDAY.GT.4)ISTART=IDAY+4
C     A MAX DELAY OF 4 OAYS FROM CURRENT DAY
      IF(R.GE.0.01)WRITE(3,61)IDAY,R,ISTART
   61 FORMAT('0','DAY NO.=',I4,4X,'RAIN=',F5.2,4X,'DELAY UNTIL DAY=',I4)
   71 CONTINUF
      RETURN
      END



      SUBROUTINE RAIN(R,X,NN)
      DIMENSION X(1)
      R=0.
      RETURN
      END



      SUBROUTINE ARR(R,X,NN,AR,NDAY,IG,VOL,IAP,SA,NA,NB,NC,IARFLG)
      REAL NA,NB,NC
      DIMENSION X(1)
      IG=0
      DATA NBLNK/0/,NSTART/0/
      IF(NDAY.LT.NSTART) IG=1
      IF(NDAY.LT.NSTART)GO TO 1
      IF(R.GT.0)GO TO 2
      IF(IAR.GT.0) GO TO 1
      XA=NDAY-NBLNK
      IF(IARFLG.EQ.1) GO TO 10
      SA=148.456/((VOL)**0.4426)
      SA=3.37
      NA=0.0027*VOL-3.52-6.0
      NB=100./SA+0.67*NA-2.67
      NC=NB+8.
10    FOX=((XA/NA)**2)*SA
```

PROGRAM LISTING—Continued

```
      IF(XA.GT.NA)FOX=SA
      IF(XA.GT.NB)FOX=(((NC-XA)/8.)**2)*SA
      IF(XA.GT.NC)FOX=0.
      AAR=FOX*VOL/100.
      ARSIG=AAR/2.5
      CALL GAUSS(X,NN,ARSIG,AAR,AR)
      IF(AR.LT.0.)AR=0.
      GO TO 3
2     N=1.5*X(1)
      IG=N
      NSTART=NDAY+N
    1 NBLNK=NBLNK+1
      AR=0
    3 RETURN
      END



      SUBROUTINE GAUSS(X,NN,S,AM,Y)
      DIMENSION X(1)
      A=0.0
      DO 50 I=1,12
      X(1)=X(1)*8192.*16384.
      CALL RANDU(X,NN)
      Y=X(1)
50    A=A+Y
      Y=(A-6.0)*S+AM
      RETURN
      END



      SUBROUTINE RANDU(X,N)
      DIMENSION X(1)
      K=316227
      NK=N*K
      RN=N
      R=RN/34359738367.
      X(1)=ABS(R)
      N=NK
      RETURN
      END
```

EXAMPLE RUN

Input Data

```
1     1    14     6     1           2.5       18.5       1.60       12.0       0.10
  25.10         0.93    200.00
  20.00         1.00    400.00
   5.00         1.40    250.00
  12.50         1.20     75.00
  51.10         1.00    250.00
  30.00         1.00    400.00
 305
0.000.000.080.080.100.100.100.100.100.200.200.200.250.250.300.300.300.300.350.40
0.400.400.500.500.500.600.650.700.700.700.800.800.800.900.900.900.900.900.900.90
0.950.950.950.951.001.001.001.001.001.000.000.000.000.000.000.100.100.100.100.20
0.200.300.400.400.400.400.400.400.500.500.500.500.500.500.500.500.700.700.800.80
0.900.900.950.951.001.001.001.001.001.001.001.001.001.001.001.001.001.001.001.00
0.000.000.080.080.100.100.100.100.100.200.200.200.250.250.300.300.300.300.350.40
0.400.400.500.500.500.600.650.700.700.700.800.800.800.900.900.900.900.900.900.90
0.950.950.950.951.001.001.001.001.001.000.000.000.000.000.000.100.100.100.100.20
0.200.300.400.400.400.400.400.400.500.500.500.500.500.500.500.500.700.700.800.80
0.900.900.950.951.001.001.001.001.001.001.001.001.001.001.001.001.001.001.001.00
0.000.000.080.080.100.100.100.100.100.200.200.200.250.250.300.300.300.300.350.40
0.400.400.500.500.500.600.650.700.700.700.800.800.800.900.900.900.900.900.900.90
0.950.950.950.951.001.001.001.001.001.000.000.000.000.000.000.100.100.100.100.20
0.200.300.400.400.400.400.400.400.500.500.500.500.500.500.500.500.700.700.800.80
0.900.900.950.951.001.001.001.001.001.001.001.001.001.001.001.001.001.001.001.00


   108.30       0.059    7149.00  13175.00    3000.00     8    1584.00
      5.0       0.28         5.0      3.37    12    34    42     1
   1   10
322   .22   327   .15   335   .02   336   .02   337   .47   340   .36   343   .01   344   .02
350   .04   363   .01
    0.002    40   100        0.800
   1  314   333     4
```

Output Data

```
        HARVEST-GIN  FOR N.C. STATE EXAMPLE

                NO.HARV.  NO.TRAILERS   TRAILER CAP.  DIST.TO GIN

                   1          14           7767.6          2.5

  FIELD                ACRES              YIELD          ROW LENGTH
    1                  25.10                .93            200.00
    2                  20.00               1.00            400.00
    3                   5.00               1.40            250.00
    4                  12.50               1.20             75.00
    5                  51.10               1.00            250.00
    6                  30.00               1.00            400.00
GIN STARTING DAY IS 314

HARV. STARTING DAY IS 333

TOTAL COTTON TO HARVEST IS  379168.6POUNDS


      DAILY HARVESTING SUMMARY

    HOURS       TOTAL ACRES   TOTAL COTTON   HARVESTER      WHICH HARVEST
  OPERATION     HARVESTED     HARVESTED     IDLE TIME

   1  6             .00            .0           .0            1

GIN BREAKS DOWN AT TIME  87  OF DAY 319  REPAIR TIME IS  -4.2  TIME INCREMENTS


                          DAILY GIN SUMMARY

DAY NO. NO.ARRIVALS   BALES GINNED  TOTAL BALES    TOTAL BALES  CURRENT   OPERATING
            BALES        TODAY       RECEIVED       GINNED.     BACKLOG  HOURS TODAY


  319      38.1        37.4         90.            90.          .6         11
```

Output Data—Continued

```
       DAILY HARVESTING SUMMARY

  HOURS         TOTAL ACRES    TOTAL COTTON    HARVESTER       WHICH HARVEST
OPERATION       HARVESTED      HARVESTED       IDLE TIME

  1  6            .00              .0              .0              1

                              DAILY GIN SUMMARY

DAY NO. NO.ARRIVALS   BALES GINNED   TOTAL BALES     TOTAL BALES   CURRENT    OPERATING
           BALES         TODAY         RECEIVED        GINNED      BACKLOG    HOURS TODAY

  320      39.9          39.2          130.            129.          .7          11


       DAILY HARVESTING SUMMARY

  HOURS         TOTAL ACRES    TOTAL COTTON    HARVESTER       WHICH HARVEST
OPERATION       HARVESTED      HARVESTED       IDLE TIME

  1  6            .00              .0              .0              1

                              DAILY GIN SUMMARY

DAY NO. NO.ARRIVALS   BALES GINNED   TOTAL BALES     TOTAL BALES   CURRENT    OPERATING
           BALES         TODAY         RECEIVED        GINNED      BACKLOG    HOURS TODAY

  321      84.6          69.4          213.            198.         14.4         11


       DAILY HARVESTING SUMMARY

  HOURS         TOTAL ACRES    TOTAL COTTON    HARVESTER       WHICH HARVEST
OPERATION       HARVESTED      HARVESTED       IDLE TIME

  1  6            .00              .0              .0              1

                              DAILY GIN SUMMARY

DAY NO. NO.ARRIVALS   BALES GINNED   TOTAL BALES     TOTAL BALES   CURRENT    OPERATING
           BALES         TODAY         RECEIVED        GINNED      BACKLOG    HOURS TODAY

  333     247.5         357.9          847             847.          .0          23


       DAILY HARVESTING SUMMARY

  HOURS         TOTAL ACRES    TOTAL COTTON    HARVESTER       WHICH HARVEST
OPERATION       HARVESTED      HARVESTED       IDLE TIME

  1  6           5.98           10148.9            .0              1

TRAILER NO.   2  IS SELECTED TO BE FILLED AT TIME  43  OF DAY 334  BY HARVESTER 1
                      HARVESTER NO. 1HAS  2075.1LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  2
      DAY 334TIME  43                         FIELD NO.   1        IDLE TIME=  0.
WHICH NOW HAS    2075.1LBS. OF SEED COTTON
HARVESTER NO.    1BREAKS DOWN, TIME  47OF DAY 334         REPAIR TIME IS  -1.9TIME INCREMENTS
HARVESTER NO.    1BREAKS DOWN, TIME  48OF DAY 334         REPAIR TIME IS -10.0TIME INCREMENTS
                      HARVESTER NO. 1HAS  2227.3LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  2
      DAY 334TIME  57                         FIELD NO.   1        IDLE TIME=  0.
WHICH NOW HAS    4302.5LBS. OF SEED COTTON
                                  .516        A,B,C,EFF
    891.1    490.2     68.1
                      HARVESTER NO. 1HAS  2197.5LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  2
      DAY 334TIME  64                         FIELD NO.   1        IDLE TIME=  0.
WHICH NOW HAS    6500.0LBS. OF SEED COTTON
TRAILER NO.   2  WAS FILLED AT TIME  71
                      HARVESTER NO. 1HAS  2305.1LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  2
      DAY 334TIME  71                         FIELD NO.   1        IDLE TIME=  0.
WHICH NOW HAS    8805.1LBS. OF SEED COTTON
TRAILER NO.   1  LEAVES FOR GIN AT TIME  71   OF DAY 334. GIN BACKLOG IS     6.5  BALES
TRAILER NO.   1  ENTERS GIN QUEUE AT TIME  75
TRAILER NO.   3  IS SELECTED TO BE FILLED AT TIME  77  OF DAY 334  BY HARVESTER I
                      HARVESTER NO. 1HAS  2098.0LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  3
      DAY 334TIME  77                         FIELD NO.   I        IDLE TIME=  0.
WHICH NOW HAS    2098.0LBS. OF SEED COTTON
TRAILER NO.   1  IS GINNED. TIME IS  78
                      HARVESTER NO. 1HAS  2406.7LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  3
      DAY 334TIME  84                         FIELD NO.   1        IDLE TIME=  0.
WHICH NOW HAS    4504.7LBS. OF SEED COTTON
                      HARVESTER NO. 1HAS  2074.4LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  3
      DAY 334TIME  90                         FIELD NO.   1        IDLE TIME=  0.
WHICH NOW HAS    6579.2LBS. OF SEED COTTON
TRAILER NO.   3  WAS FILLED AT TIME  97
                      HARVESTER NO. 1HAS  2387.5LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  3
      DAY 334TIME  97                         FIELD NO.   1        IDLE TIME=  0.
WHICH NOW HAS    8966.7LBS. OF SEED COTTON
TRAILER NO.   2  LEAVES FOR GIN AT TIME  97   OF DAY 334. GIN BACKLOG IS     9.1  BALES
TRAILER NO.   2  ENTERS GIH QUEUE AT TIME 101
```

Output Data—Continued

```
                               DAILY GIN SUMMARY

 DAY NO. NO.ARRIVALS    BALES GINNED  TOTAL BALES      TOTAL BALES  CURRENT    OPERATING
              BALES          TODAY        RECEIVED        GINNED      BACKLOG   HOURS TODAY


   334       110.3        108.0        956.            955.          .5          11


     DAILY HARVESTING SUMMARY

    HOURS        TOTAL ACRES    TOTAL COTTON    HARVESTER      WHICH HARVEST
  OPERATION      HARVESTED      HARVESTED      IDLE TIME

   1  6           16.72          27889.5           .0             1

YLOS=        .00



                               DAILY GIN SUMMARY

 DAY NO. NO.ARRIVALS    BALES GINNED  TOTAL BALES      TOTAL BALES  CURRENT    OPERATING
              BALES          TODAY        RECEIVED        GINNED      BACKLOG   HOURS TODAY


   360       180.5        361.9       3010.            3000.        10.3         23


     DAILY HARVESTING SUMMARY

    HOURS        TOTAL ACRES    TOTAL COTTON    HARVESTER      WHICH HARVEST
  OPERATION      HARVESTED      HARVESTED      IDLE TIME

       6         103.17         269287.1           .0             1

YLOS=     3641.90
TRAILER NO.    1  RETURNS TO FARM AT TIME    5  OF DAY 361
TRAILER NO.    2  RETURNS TO FARM AT TIME    5  OF DAY 361
TRAILER NO.    4  RETURNS TO FARM AT TIME    9  OF DAY 361
TRAILER NO.    5  RETURNS TO FARM AT TIME    9  OF DAY 361
TRAILER NO.    3  IS GINNED. TIME IS  43
TRAILER NO.   1  IS SELECTED TO BE FILLED AT TIME  44  OF DAY 361  BY HARVESTER 1
      DAY 361TIME  44       HARVESTER NO. 1HAS  2399.6LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  1
WHICH NOW HAS     2399.6LBS. OF SEED COTTON            FIELD NO.     5       IDLE TIME=  0.
      DAY 361TIME  48       HARVESTER NO. 1HAS  2262.3LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  1
WHICH NOW HAS     4661.9LBS. OF SEED COTTON            FIELD NO.     5       IDLE TIME=  0.
      DAY 361TIME  52       HARVESTER NO. 1HAS  2179.6LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  1
WHICH NOW HAS     6841.5LBS. OF SEED COTTON            FIELD NO.     5       IDLE TIME=  0.
TRAILER NO.    1  WAS FILLED AT TIME  57
      DAY 361TIME  57       HARVESTER NO. 1HAS  2567.5LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  1
WHICH NOW HAS     9409.0LBS. OF SEED COTTON            FIELD NO.     5       IDLE TIME=  0.
TRAILER NO.    1  LEAVES FOR GIN AT TIME  57
HARVESTER NO.    1BREAKS DOWN, TIME  60OF DAY 361       REPAIR TIME IS  -3.3TIME INCREMENTS
   893.0   392.2    98.7         .546       A.B,C,EFF
TRAILER NO.    1  ENTERS GIN QUEUE AT TIME  61    OF DAY 361. GIN BACKLOG IS      81.0  BALES
TRAILER NO.    3  RETURNS TO FARM AT TIME  63  OF DAY 361
TRAILER NO.  2  IS SELECTED TO BE FILLED AT TIME  64  OF DAY 361  BY HARVESTER 1
      DAY 361TIME  64       HARVESTER NO. 1HAS  2356.2LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  2
WHICH NOW HAS     2356.2LBS. OF SEED COTTON            FIELD NO.     5       IDLE TIME=  0.
      DAY 361TIME  68       HARVESTER NO. 1HAS  2112.0LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  2
WHICH NOW HAS     4468.2LBS. OF SEED COTTON            FIELD NO.     5       IDLE TIME=  0.

         COMPLETED HARVESTING FIELD NO.     5      ON DAY   361      THIS FIELD HAS BEEN HARVESTER 1 TIME
REMAINING COTTON IS       1573.




YA       .01189
      DAY 361TIME  72       HARVESTER NO. 1HAS  2418.6LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  2
WHICH NOW HAS     6886.8LBS. OF SEED COTTON            FIELD NO.     6       IDLE TIME=  0.
TRAILER NO.    2  WAS FILLED AT TIME  76
      DAY 361TIME  76       HARVESTER NO. 1HAS  2382.9LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  2
WHICH NOW HAS     9269.7LBS. OF SEED COTTON            FIELD NO.     6       IDLE TIME=  0.
TRAILER NO.    2  LEAVES FOR GIN AT TIME  76
TRAILER NO.   3  IS SELECTED TO BE FILLED AT TIME  80  OF DAY 361  BY HARVESTER 1
      DAY 361TIME  80       HARVESTER NO. 1HAS  2389.8LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  3
WHICH NOW HAS     2389.8LBS. OF SEED COTTON            FIELD NO.     6       IDLE TIME=  0.
TRAILER NO.    2  ENTERS GIN QUEUE AT TIME  80   OF DAY 361. GIN BACKLOG IS     156.4  BALES
      DAY 361TIME  84       HARVESTER NO. 1HAS  2334.3LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  3
WHICH NOW HAS     4724.1LBS. OF SEED COTTON            FIELD NO.     6       IDLE TIME=  0.
      DAY 361TIME  88       HARVESTER NO. 1HAS  2320.7LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  3
WHICH NOW HAS     7044.9LBS. OF SEED COTTON            FIELD NO.     6       IDLE TIME=  0.
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Output Data—Continued

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TRAILER NO.   3  WAS FILLED AT TIME  92
      DAY 361TIME  92       HARVESTER NO. 1HAS  2480.9LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  3
WHICH NOW HAS     9525.8LBS. OF SEED COTTON             FIELD NO.    6      IDLE TIME=  0.
TRAILER NO.   3  LEAVES FOR GIN AT TIME  92
GIN BREAKS DOWN AT TIME  92  OF DAY 361  REPAIR TIME IS -11.0  TIME INCREMENTS
TRAILER NO.   4  IS SELECTED TO BE FILLED AT TIME  96  OF DAY 361  BY HARVESTER 1
      DAY 361TIME  96       HARVESTER NO. 1HAS  2634.2LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  4
WHICH NOW HAS     2634.2LBS. OF SEED COTTON             FIELD NO.    6      IDLE TIME=  0.
TRAILER NO.   3  ENTERS GIN QUEUE AT TIME  96   OF DAY 361. GIN BACKLOG IS    208.2  BALES
      DAY 361TIME 100       HARVESTER NO. 1HAS  2572.8LBS. OF SEED COTTON BEING DUMPED INTO TRAILER  4
WHICH NOW HAS     5207.1LBS. OF SEED COTTON             FIELD NO.    6      IDLE TIME=  0.


          TRAILER UTILIZATION

   TRAILER        EMPTY       FULL
         1         21.0            55.2
         2         34.7            41.5
         3         44.2            32.0
         4         50.7            25.5
         5         28.9            47.3
         6         57.6            18.6
         7         69.5             6.7
         8         71.1             5.1
         9         76.2              .0
        10         76.2              .0
        11         76.2              .0
        12         76.2              .0
        13         76.2              .0
        14         76.2              .0
BALES HARVESTED- 140.0

HOURS OPERATION PER HARVESTER-  59.58

DAYS LABOR CHARGED FOR HARVESTING   31

HARVESTER COST         2235.20
GINNING COST           3456.99
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TOTAL COST PER BALE IS 61.77FOR HARVESTING , HAULING , AND GINNING


@BRKPT   PRINT$
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